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(6) STOCKAGE POLICY ANALYSIS.

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ANNEX A.

COMPONENT DOCUMENTATION

OF

DoD INSTRUCTION 4140.39

VSL/EOQ POLICY IMPLEMENTATION.

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PART 2.

AUGUST 31, 1980

STOCKAGE POLICY ANALYSIS

ANNEX A

COMPONENT DOCUMENTATION

OF

DoD INSTRUCTION 4140.39

VSL/EOQ POLICY IMPLEMENTATION

PART 2

AUGUST 31, 1980

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1.0 DLA DOCUMENTATION OF VSL/EOQ IMPLEMENTATION

DLA

IMPLEMENTATION

OF

DODI 4140.39

SAFETY LEVELS AND PROCUREMENT

CYCLES

Slide #1

This presentation describes the DLA implementation in the Standard Automated Materiel Management System (SAMMS) of the standard inventory model prescribed in DODI 4140.39. In addition to covering data collection and forecasting it will also cover the computation of safety levels, procurement cycles, and some of the unique techniques used by DLA for Program Data Application. The presentation covers the use of essentiality as well as goals, constraints, parameters, relative sensitivity and problems. The presentation concludes with some recommendations for future improvements of the system.

DATA COLLECTION

- o DEMAND RECORDING
  - oo REQUISITIONS
  - oo CANCELLATIONS
  - oo FILL OR KILL
  - oo POST-POST ISSUES
  - oo RETURNS
  - oo MANAGER ACTIONS
  - oo PROCESSED DAILY

Slide #2

Demand is recorded as soon as a positive supply action, that is the preparation of a Material Release Order or the establishment of a backorder, is accomplished on a requisition. Requisitions, cancellations, issues, returns and manager actions are processed daily. Actual recording takes place with the running of a requirements cycle two or three times a week.

DATA COLLECTION

- o ELEMENTS RECORDED
  - oo QUANTITY
  - oo FREQUENCY
  - oo MILSTRIP DEMAND CODE
  - oo RIC PRIME
  - oo CUSTOMER ZONE CODE
  - oo SERVICE CODE
  - oo NIIN
- o PERIODS MAINTAINED
  - oo CURRENT MONTH
  - oo PREVIOUS MONTH
  - oo CURRENT QUARTER
  - oo FOUR PREVIOUS QUARTERS

Slide #3

In recording demand DLA records the following elements: demand quantity and demand frequency. The system perpetuates the Military Standard Requisitioning and Issue Procedure (MILSTRIP) demand code from the requisition document. The Routing Identification Code of the depot most cost effective to support the customer, the Customer Zone Code (which indicates east coast CONUS, west coast CONUS, Europe or Pacific), the customer's Service Code and the National Item Identification Number (NIIN) of the stock number requisitioned are also recorded. Records are maintained for the current month, the previous month, the current calendar quarter and the four previous calendar quarters.

DATA COLLECTION

- LEAD TIME REPORTING
  - AWARD-ALT AND PLT
  - DELIVERY-PLT UPDATE
  - PROCESSED WEEKLY
  - SINGLE SMOOTHED AVERAGE
  - FOUR PREVIOUS OBSERVATIONS AND CURRENT AVERAGE MAINTAINED IN HISTORY
- PROVISION FOR MANAGER REVIEW

Slide #4

Weekly, leadtimes are computed for those items for which buys have been awarded or for which deliveries have been made. At the time of award, SAMMS updates and recomputes both the administrative leadtime, based on the time between the output of the recommended buy and the date of award, and the production leadtime, based on the contract delivery date. At the time of delivery of the first significant increment of material, the production leadtime is recomputed, based on the time between the contract award date and the actual delivery date. These are processed weekly and maintained in the supply control file as single smoothed averages. There is also a separate leadtime history file with the four previous observations of each leadtime and the current average. There is a provision in the system for manager review of leadtime changes when they exceed certain pre-set parameters.

FORECASTING

- REPLENISHMENT DEMAND ITEMS
- MONTHLY AND QUARTERLY
- SINGLE AND DOUBLE SMOOTHING
- LOCATION - SINGLE SMOOTHED
- SYSTEM - DOUBLE SMOOTHED

Slide #5

All replenishment demand items are forecast quarterly. A provision exists to forecast items on a monthly basis as well. DLA uses single and double smoothing. SAMMS computes location single smoothed forecasts and a system double smoothed forecast for each item.

FORECASTING

- o ELEMENTS OF THE FORECAST
  - oo DEMANDS (D)
  - oo APPLICABLE NONRECURRING DEMAND PERCENTAGE (ANRDP)
  - oo PROPORTION OF RECURRING DEMAND ALLOCABLE (PRDA)
  - oo QUARTERLY FORECAST OF DEMAND (QFD)
  - oo SINGLE SMOOTHED AVERAGE (SS)
  - oo DOUBLE SMOOTHED AVERAGE (DS)
  - oo MEAN ABSOLUTE DEVIATION (MAD)
  - oo ALGEBRAIC SUM OF FORECAST ERROR (ASFE)
  - oo ALPHA FACTOR (α)

Slide #6

These are the elements of the recurring demand forecast:

Demands experienced during the previous forecast period, month or quarter,

The Applicable Non-Recurring Demand Percentage (ANRDP) which is simply the proportion of demand coded non-recurring which will be used for high demand value items,

The Proportion of Recurring Demand Allocable (PRDA) for each storage location where the material is actually stored. These are referred to as preferred storage locations for that item.

The previous Quarterly Forecast *of Demand (QFD)*,

The previous Single Smoothed Average (SS),

The previous Double Smoothed Average (DS),

The Mean Absolute Deviation of forecast error (MAD),

The Algebraic Sum of the Forecast Error (ASFE), and

The alpha factor. The alpha factor also known as the smoothing constant, is simply a number between 0 and 1 which represents the amount of weight which is placed on the most recent demand experience.

ACCUMULATION OF DEMANDS

- RECURRING DEMANDS - CODE R

- NONRECURRING DEMANDS - CODE N - FACTORED BY ANRDP FOR HIGH DEMAND VALUE ITEMS

- SPECIFIC EXCLUSIONS

  - SPECIAL PROGRAM REQUIREMENTS DEMANDS - CODE P

  - FMS DIRECT SALES - IDENTIFIED BY SERVICE CODE

Slide #7

The first step in the forecast is the accumulation of demand to be used in forecasting. DLA uses all demands bearing MILSTRIP code "R" recurring demands. For low and medium demand value items, which are those with an annual demand value of less than $4,500, all demands coded non-recurring, MILSTRIP code "N" are used. For high demand value items, those with an annual demand value of greater than $4,500, a part of the non-recurring demands is used. This proportion is the Applicable Non-Recurring Demand Percentage (ANRDP). Specifically, excluded are MILSTRIP code "P" demands, which are identified to Special Program Requirements; and FMS direct sales, which are identified by unique Service Codes.

ACCUMULATION OF DEMANDS

(CONTINUED)

- COMPUTE FORECAST ERROR (FE)

  $$FE_t = QFD_t - D_t$$

- RECOMPUTE ASFE

  $$ASFE_{t+1} = ASFE_t + FE_t$$

- RECOMPUTE MAD

  $$MAD_{t+1} = (\alpha)\ FE_t + (1-\alpha) MAD_t$$

- RECOMPUTE ANRDP

  $$ANRDP = \frac{2(A+B)}{A+B+C+D}$$

  WHERE A AND B ARE THE
  TWO LOWEST OF A, B, C AND D.

Slide #8

The forecast error is computed by comparing the quarterly forecast of demand for the quarter past with the actual demands experienced during the period. The difference between them is the forecast error. This is added to the previous Algebraic Sum of Forecast Error to maintain a continuing record of net forecast error over time. Finally, the Mean Absolute Deviation of demand is computed using the alpha factor. The absolute value of the forecast error times the alpha factor plus 1 minus the alpha factor times the previous MAD yields the new MAD. Quarterly, the ANRDP is recomputed for high demand value items. This is computed by taking the sum of non-recurring demand for the two lowest previous quarters, multiplying that by 2, and dividing by the sum of the total non-recurring demand for the four previous quarters.

LOCATION FORECAST - SINGLE SMOOTHED

- SL = LOCATION FORECAST
- $SL_t = SS_t \times PRDA_t$
- DL = LOCATION DEMAND
- $SL_{t+1} = (\alpha)DL_t + (1-\alpha)SL_t$
- $SS_{t+1} = \Sigma SL_{t+1}$
- $PRDA_{t+1} = \dfrac{SL_{t+1}}{SS_{t+1}}$
- EACH PREFERRED DEPOT HAS A PRDA

Slide #9

The location forecast is single smoothed. Each preferred storage location has a Proportion of Recurring Demand Allocable (PRDA). This is multiplied by the previous single smoothed average. This is then smoothed against the demand experienced against that location during the previous period using the alpha factor. This is done for each preferred storage location. The results are summed to give a new system single smoothed average. The PRDA is then recomputed by division for each preferred storage location.

SYSTEM FORECAST - DOUBLE SMOOTHED

- $DS_{t+1} = (\alpha)SS_{t+1} + (1-\alpha)DS_t$

- $QFD_{t+1} = 2SS_{t+1} - DS_{t+1}$

EXPLOIT THE DIFFERENCE BETWEEN THE SINGLE AND DOUBLE SMOOTHED AVERAGES TO INTRODUCE TREND INTO THE FORECAST

Slide #10

Using the new single smoothed system average and the old double smoothed system average, a new system double smoothed average is computed. Exploiting the difference between the single smoothed average and the double smoothed average gives the Quarterly Forecast of Demand for the next period. This perpetuates in the forecast any upward or downward trend in demand.

LEVELS FORMULAE AND THEIR DERIVATION

- POLICY - DODI 4140.39
- ECONOMIC ORDER QUANTITY
- VARIABLE SAFETY LEVEL

Slide #11

The DLA policy for the derivation of levels is taken from DODI 4140.39, using the rules in the standard inventory model to compute the Economic Order Quantity (EOQ) and the Variable Safety Level (VSL) quantity.

ECONOMIC ORDER QUANTITY

"MINIMIZE THE TOTAL OF VARIABLE ORDER AND HOLDING COSTS"

WILSON EOQ

$$Q = \sqrt{\frac{2AP}{H}}$$

A = DOLLAR VALUE OF ANNUAL DEMAND

P = VARIABLE COST TO ORDER

H = VARIABLE COST TO HOLD

Q = DOLLAR VALUE OF EOQ

Slide #12

DLA uses a simple Wilson economic order quantity to minimize the total sum of variable order costs and variable holding costs. The traditional Wilson EOQ uses the annual dollar value of demand, the cost to order, and the cost to hold.

DERIVATION OF THE EOQ

$Q = \sqrt{\frac{2AP}{H}}$ LET C_i = UNIT PRICE

$$Q_i = \sqrt{\frac{2P(QFD_i X4)C_i}{H}}$$

$$Q_i = 2\sqrt{\frac{2P(QFD_i C_i)}{H}}$$

$$Q_i = 2\sqrt{\frac{2P}{H}} \qquad \sqrt{QFD_i C_i}$$

LET $T = 2\sqrt{\frac{2P}{H}}$ AND STORE

THEN $Q_i = T\sqrt{QFD_i C_i}$

CONVERT TO MONTHS AND STORE

$$Q\ (\text{UNITS}) = \frac{Q_i}{C_i}$$

$$Q\ (\text{MONTHS}) = \frac{3Q\ (\text{UNITS})}{QFD_i}$$

Slide #13

DLA has simplified the calculations somewhat by factoring out from the basic Wilson EOQ those elements common to all items in the system. For an individual item, multiply its quarterly forecasted demand by its unit price, take the square root and multiply by the T factor which is a function of the cost to hold - cost to order ratio, which giving an EOQ in dollars. This is then converted to units, then to months and the number of whole months in the EOQ is stored in the file.

VARIABLE SAFETY LEVEL

$$RS = \sum_{i=1}^{\eta} \frac{E_i}{S_i Q_i} \int_{R_i}^{\infty} (X-R_i)\ [F(X+Q_i;L)-F(X;L)]\ dx$$

$$VSL = K_i^{\sigma_i}$$

DERIVATION AFTER PRESUTTI

Slide #14

This is the inventory model from DODI 4140.39. DLA has followed the derivation of Presutti for an individual item in the transformation of this to algebra that can be worked by the machine.

VARIABLE SAFETY LEVEL

ASSUMING:

$$f(x) = \frac{\sqrt{2}}{2} \exp\left(-\sqrt{2}\left|\frac{x-\mu}{\sigma}\right|\right)$$

MINIMIZE:

$$\sum_{i=1}^{\eta} \frac{P_i D_i}{Q_i} + \sum_{i=1}^{\eta} a_i C_i \left(\mu_i + \kappa_i \sigma_i + \frac{Q_i}{2}\right)$$

SUBJECT TO:

$$\sum_{i-1}^{\eta} \frac{0.5}{2} \frac{Z_i \sigma_i 2}{S_i Q_i} \left[1-\exp\left(-\sqrt{2}\frac{Q_i}{\sigma_i}\right)\right] \exp\left(-\sqrt{2}K_i\right) \leqq \beta$$

Z_i = RELATIVE ESSENTIALITY

β = SYSTEM BACKORDER OBJECTIVE

Slide #15

DLA assumes a normal distribution of forecast error as shown by the top equation. The second equation shows the sum of variable order costs and variable holding costs which is to be minimized and the bottom equation shows the constraint on backorders which is derived after Presutti. The beta (β) value at the end of the bottom equation becomes the management control on total safety level.

VARIABLE SAFETY LEVEL

DIFFERENTIATING:

$$K_i = -\frac{1}{\sqrt{2}} \ln \left[\frac{\sqrt{2} S_i \; Q_i \; a_i \; C_i}{0.5(-\lambda) Z_i \sigma_i (1 - \exp(-\sqrt{2} Q_i \; \sigma_i))} \right]$$

AND $$-\lambda = \sum_{i=1}^{\eta} \frac{\sigma_i \; a_i \; C_i}{\sqrt{2} \; \beta}$$

ASSUMING:

$$\sigma_i = 1.25 \text{ MAD } LT_i$$

AND COMBINING TERMS:

<u>Slide #16</u>

By differentiation, the basic safety level algebraic equation is derived.

VARIABLE SAFETY LEVEL

$$K_i = - \frac{-1}{\sqrt{2}} \ln \left[\frac{2.56\ S_i\ Q_i\ a_i\ C_i \beta}{Z_i \mathrm{MAD\ LT}_i \mathrm{SC}(1-\exp(-\sqrt{2Q_i}/1.25\ \mathrm{MAD\ LT}_i))} \right]$$

AND: $$\mathrm{SC} = \sum_{i=1}^{\eta} \mathrm{MAD\ LT}_i C_i$$

SO: $$\mathrm{VSL}_i = 1.25\ K_i \mathrm{MAD\ LT}_i$$

Slide #17

Combining terms, using the explicit solution to the LAMBDA value given by Persutti, yields this equation. This is what is actually programmed in SAMMS. The terms are:

S_i = item's average requisition quantity
Q_i = item's EOQ
C_i = item's standard price
Z_i = item's essentiality factor
$MADLT_i$ = item's mean absolute deviation of leadtime demand
β = system policy variable
SC = system independent variable

DERIVATIONS AND APPROXIMATIONS

- o $S_i = \frac{D_i}{R_i}$ AVERAGE REQUISITION QUANTITY

- o $MAD\ LT_i = (a + bT)MAD_i$
  - oo WHERE T = NUMBER OF FORECAST PERIODS IN PROCUREMENT LEADTIME
  - oo a AND b ARE FUNCTIONS OF ALPHA FACTOR
  - oo TYPICALLY, $a = 0.55$, $b = 0.49$ FOR $\alpha = 0.20$

- o TABLES USED TO APPROXIMATE LOGARITHMIC AND EXPONENTIAL FUNCTIONS

- o β VALUE INPUT BY MANAGEMENT BASED ON APPROVED FUNDING LEVELS

Slide #18

The average requisition quantity is computed by dividing the demand quantity for the previous four quarters by the demand frequency for the previous four quarters. As an approximation of demand variance over leadtime, the MAD is factored by the second equation, where A and B are functions of the alpha factor. T is the number of forecast periods, months or quarters, in the total procurement leadtime. Because SAMMS is programmed in COBOL and COBOL does not do logarithmic and exponential functions very well, a series of tables are used to approximate those to three significant digits. The beta value is input by management based upon approved budget levels. There is an inverse correlation between the beta value and the system safety level requirement.

PROGRAM DATA APPLICATION

- SYSTEM PROVISION
- 4 SETS OF PROGRAM CHANGE FACTORS
- FORECAST BY SERVICE
- QFD ADJUSTED BY SERVICE FORECAST TIMES PROGRAM CHANGE FACTOR
- PROJECTED REQUIREMENTS FOR NEXT TWELVE QUARTERS ADJUSTED BY PROGRAM CHANGE FACTORS
- NOT USED AT PRESENT

Slide #19

The DLA system also has a provision for the use of program change factors in forecasting. This has never been used in practice, although it has been extensively tested and may be used in the future. Four sets of program change factors are stored, by quarter, for 3 years, 12 calendar quarters. The forecast is done by Service, applying each Service's program change factors for the applicable program, projecting requirements for the next 12 quarters.

ESSENTIALITY

- ESSENTIALITY FACTOR USED IN VSL COMPUTATION - Z_i
- CONSTANT 1 FOR ALL ITEMS
- EXCEPTION - DEFENSE ELECTRONICS SUPPLY CENTER
  - o Z_i = 6 FOR ALL ITEMS WITH 200+ ANNUAL REQUISITION FREQUENCY
  - oo Z_i = 2 FOR ALL ITEMS WITH 20-199 ANNUAL REQUISITION FREQUENCY AND $4500+ ANNUAL DEMAND VALUE

Slide #20

The principal provision for essentiality in SAMMS is the essentiality factor which is specified in the DODI 4140.39 inventory model and which is used in the variable safety level computation. This is a constant one for all DLA items, except at the Defense Electronics Supply Center where items with an annual requisition frequency of 200 or more use a safety level essentiality factor up to 6 and items with a requisition frequency of 20 to 200 annually and $4,500 or more in annual demand use an essentiality factor of 2.

ASSUMPTIONS

- NORMAL DISTRIBUTION OF FORECAST ERROR
- DETERMINISTIC LEADTIME
- ACQUISITION PRICE APPROXIMATES STANDARD PRICE
- INVESTMENT COST STATIC

Slide #21

These are some of the assumptions that the system is based on. DLA assumes a normal distribution of forecast error. Leadtimes are assumed to be deterministic and correct. The acquisition price is assumed to approximate the standard price, which is the price used in the calculation. A continuous review system is also assumed.

GOALS

- FOR BUDGETING - CONSTRUCT SYSTEM SAFETY LEVEL REQUIREMENT TO CONFORM TO FUNDING LEVEL
- THEORETICAL - MINIMIZE BACKORDERS OUTSTANDING AT A GIVEN POINT IN TIME
- NET EFFECT - MINIMIZE TIME-WEIGHTED REQUISITIONS SHORT
- EOQ - EQUATE THE ANNUAL VARIABLE COSTS OF ORDERING AND HOLDING MATERIEL AND SO MINIMIZE THE SUM

Slide #22

The budgeting goal is to construct system variable safety levels to conform to approved funding levels. Theoretically, this is done in such a way as to minimize backorders outstanding at a given point in time, the net effect of which is to minimize time weighted requisitions short. The goal in the Economic Order Quantity computation is to equate the annual variable cost of holding and ordering in material and thus minimize the sum of those costs.

CONSTRAINTS

- o EOQ
  - oo THREE MONTH MINIMUM
  - oo THIRTY-SIX MONTH MAXIMUM
  - oo EXCEPTIONS - SHELF LIFE AND HAZARDOUS MATERIEL CONSTRAINED TO SMALLER MAXIMA
- o VSL
  - oo MINIMUM OF ZERO
  - oo MAXIMUM OF THREE STANDARD DEVIATIONS (3.75 MAD LT_i) OR MEAN LEADTIME DEMAND, WHICHEVER IS LESS
  - oo SPECIAL CASES:
    - ooo IF NO DEMAND IN LAST TWELVE MONTHS, VSL = 0
    - ooo IF NECESSARY, SYSTEM VSL WILL BE INCREASED TO COVER FLEET ISSUE LOAD LIST (FILL) REQUIREMENTS AT NSC NORFOLK OR OAKLAND

Slide #23

DODI 4140.39 dictates a 3 month minimum Economic Order Quantity and a 36 maximum Economic Order Quantity. DLA conforms to the letter of those constraints. There are some exceptions to using the computed Economic Order Quantity, particularly in the area of seasonal buy items; and shelf life items and hazardous material which are generally constrained to smaller maxima. The minimum safety level quantity is 0. DLA does not compute negative safety levels. The maximum is 3 standard deviations of leadtime demand or the mean leadtime demand itself whichever is less. Very low demand value items frequently top out on the mean leadtime demand. Two special cases should be addressed:

If there has been no demand in the past 12 months, a zero safety level quantity is automatically assigned.

If fleet issue load list requirements exist at Norfolk or Oakland, the system safety level will be increased to cover those requirements at those locations.

PARAMETERS

	T FACTOR	β	SC (000)	IMPLIED $-\lambda$
DCSC	74	17,500	74,500	677
DESC	74	39,000	85,318	348
DGSC	74	7,500	84,353	1,789
DISC	74	40,000	123,400	491
DPSC	95	1,500	31,078	3,296

Slide #24

These are the parameters that are used in the EOQ and VSL computations at each of the Defense Supply Centers.

RELATIVE SENSITIVITY

RANK	ELEMENT	EFFECT
1.	$MADLT_i$	DIRECT +, LOG +, LOG LOG +
2.	Q_i (EOQ)	LOG -, LOG LOG -
3.	S_i (ARQ)	LOG -
4.	C_i (PRICE)	LOG -
5.	Z_i (SLEF)	LOG +
6.	β (B/O GOAL)	LOG -
7.	SYS. CONS	LOG +

Slide #25

This graphic ranks the elements of the safety level computation approximately, from the top down, with their relative sensitivity, the most sensitive, is the variation in demand over leadtime. In descending order, the Economic Order Quantity, the average requisition quantity, the unit price, the essentiality factor, and finally the two system constraints: the management constraint - the backorder goal and the system constant, which is the sum of the dollar value of mean absolute deviation of leadtime demand for each item in the system.

PROBLEMS

- LEADTIMES NOT DEPENDABLE - CONTRACT DELINQUENCIES
- POOR CORRELATION BETWEEN β AND BACKORDERS ACTUALLY EXPERIENCED
- ICP ACCEPTANCE
- BUDGET PROBLEMS

  NO CORRELATION TO BACKORDER GOALS

  REQUIREMENT EXPRESSED IN DAYS

Slide #26

DLA problems with the safety level and economic order quantity formulas are basically the same ones that the other Components have. On the order of 50 to 60% of DLA contracts are a month or more delinquent and thus the assumption of deterministic and correct leadtime used in the formula simply does not hold a great deal of time. There is a poor correlation due to this between the beta value input into the safety level computation and the backorders actually experienced in practice. DLA has had a few problems with ICP acceptance of the use of this inventory model - partially from lack of understanding, but also because it tends to restrict the amount of safety stock on items with high unit prices. The Defense Supply Centers tend to see these high value items as being essential and fail understand why they don't get any safety stock. Finally, budget goals have very little correlation with backorder goals. Budget requirements for safety levels are expressed in days of supply rather than in standard deviations of leadtime demand.

RECOMMENDATIONS

- RECOGNIZE, MEASURE, AND ACCOUNT FOR LEADTIME VARIATION
- RECONSIDER OBJECTIVE FUNCTION
- RECONSIDER LEADTIME CONSTRAINT
- DEVELOP MODEL BASED ON COMBINATION OF BACKORDER AND LOST SALE CASES FOR SUBSISTENCE

Slide #27

The recommendations here reflect not only DLA headquarters but recommendations of the Defense Supply Centers. The principal recommendation is to recognize, measure and account for leadtime variation. There have been appeals to reconsider the objective function of time weighted requisition short. The feeling is that if ICPs are to be judged on instant supply availability, then that should be the objective function of the safety level. The constraint of mean leadtime demand on the total safety level quantity has also been questioned.

2.0 NAVY DOCUMENTATION OF VSL/EOQ IMPLEMENTATION

NAVY IMPLEMENTATION

OF

VSL/EOQ POLICIES

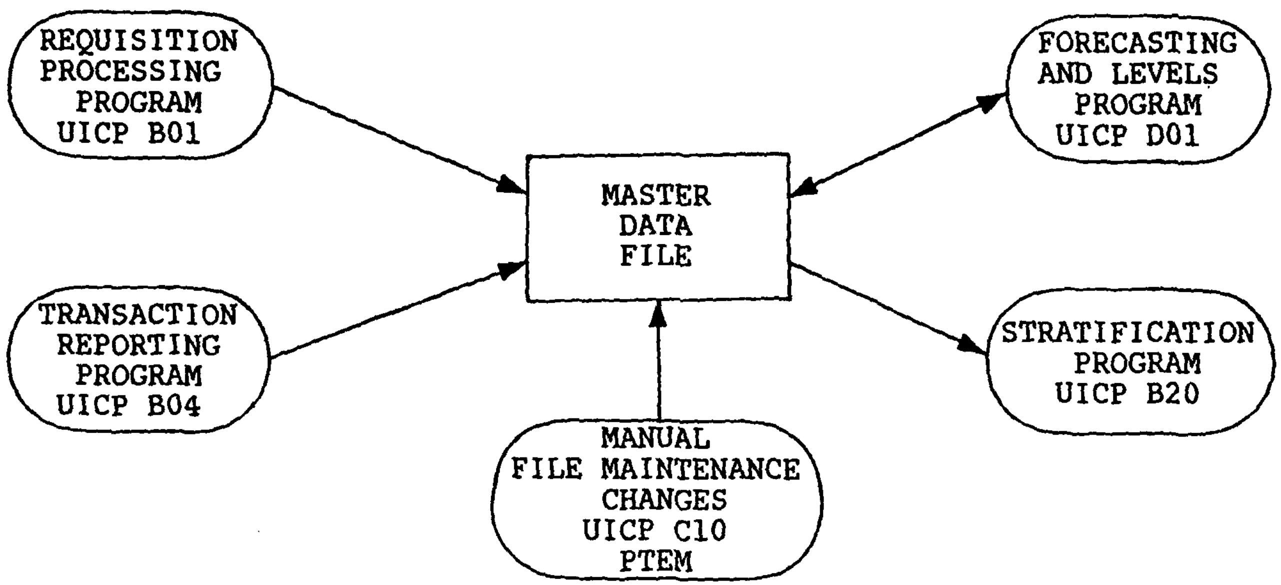
Slide #1

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

This presentation covers Navy's mechanized implementation of ASD(MRA&L) policies concerning Variable Safety Levels (VSL)/Economic Order Quantities (EOQ)/ Economic Repair Quantities (ERQ) for the procurement of consumable and depot level repairable secondary items and the repair of depot level repairable secondary items. The presentation also discusses manual file maintenance adjustments to data elements affecting VSL, EOQ and ERQ computed quantities as well as to actual procurement and repair recommendations.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

MECHANIZED SYSTEM OVERVIEW



Slide #2

MECHANIZED SYSTEM OVERVIEW

Before beginning the discussion of the implementation details, an overview of Navy's mechanized system is presented.

The mechanized system is called UICP -- the Uniform Inventory Control Program system. This system is composed of a series of online and tape files together with a series of Automated Data Processing (ADP) programs which are aligned to various specific functions (such as, Requisition Processing, Financial Accounting, etc.).

Concerning the mechanized implementation of VSL/EOQ/ERQ policies, the discussion will center on the file and ADP programs shown here. The principal inventory control file is the Master Data File (MDF) whose records are keyed by National Item Identification Number (NIIN) and contain hundreds of data elements reflecting characteristics of the items. For example, demand observations, demand forecasts, leadtime observations, leadtime forecasts, unit costs, standard prices, etc.

The primary ADP programs which collect observations used in forecasting and load those observations into the MDF are the Requisition Processing program (designated B01 in the UICP system) and the Transaction Reporting program (B04 in UICP). The primary program using these observations to compute forecasts is the Cyclic Forecasting and Levels program -- called Levels, for short -- D01 in UICP. The Levels program also loads the computed forecasts into the

Slide #2 (Continued)

MECHANIZED SYSTEM OVERVIEW

(Continued)

MDF and utilizes those forecasts for computing inventory levels requirements for budget execution purposes. The Stratification program (B20 in the UICP system) extracts the forecasts, loaded in the MDF by the Levels program, and computes inventory levels requirements for budget formulation purposes.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

DATA COLLECTION SYSTEM

- o REQUISITION PROCESSING PROGRAM (UICP PROGRAM B01)
  - oo CENTRAL-CONTROLLED ISSUES TO CUSTOMERS
  - oo OBSERVATIONS COLLECTED
    - RECURRING DEMAND UNITS
    - RECURRING DEMAND FREQUENCY
    - NONRECURRING DEMAND UNITS
  - oo COLLECTED IN QUARTERLY "BUCKETS"
    - UICP ONLINE FILE = MASTER DATA FILE
    - USED IN QUARTERLY FORECASTING OF DATA

Slide #3

DATA COLLECTION SYSTEM

First, a few words describing the decentralized wholesale system used by the Navy. The Navy computes wholesale requirements as though a single-warehouse system exists. Once such a computation is made, the requirements (and associated assets) are allocated to several wholesale level stock point locations near the principal customers. In general, the stock points may issue wholesale material to customers, who submit their requisitions to the stock points rather than directly to the Inventory Control Point (ICP). The stock points communicate those issues and other item transactions (e.g., receipts from ICP contracts, receipts from repair points, transfers to disposal, etc.) daily to the ICPs.

A. Requisition Processing Program

There are certain classes of items which are centrally controlled. That is, the customers' requisitions are submitted directly to the ICP for review prior to issuance. Those requisitions, as well as requisitions submitted by retail stock points to replenish intermediate levels of stocks and requisitions referred to the ICP by stock points without on-hand assets, are processed at the ICP by the UICP Requisition Processing Program (B01). The Requisition Processing program, among other things, collects the observations of recurring demand (units and frequency) and nonrecurring demand units. This information is collected for each item in the Master Data File (MDF) in cumulative data element "buckets" whose time base is quarters. The quarter time base is used because the Cyclic Forecasting and Levels program (D01) is designed to be run quarterly for all items.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

DATA COLLECTION SYSTEM

- o DAILY TRANSACTION REPORTING FROM STOCK POINTS (UICP PROGRAM B04)
  - oo DECENTRALIZED ISSUES TO CUSTOMERS
  - oo OBSERVATIONS COLLECTED
    - RECURRING DEMAND UNITS
    - RECURRING DEMAND FREQUENCY
    - NONRECURRING DEMAND UNITS
    - NOT-READY-FOR-ISSUES CARCASS RETURNS UNITS
    - PROCUREMENT LEADTIME
    - PRODUCTION LEADTIME
    - REPAIR IN PROCESS TIME
    - REPAIR SURVIVAL RATES (INDIRECTLY)
  - oo COLLECTED IN QUARTERLY "BUCKETS"
    - UICP ONLINE FILE = MASTER DATA FILE
    - USED IN QUARTERLY FORECASTING OF DATA

Slide #4

DATA COLLECTION SYSTEM
(Continued)

B. Transaction Reporting

The decentralized issues of stock mentioned before are collected in the same cumulative quarterly Master Data File (MDF) "buckets" via the UICP Transaction Reporting program (B04). In addition to issues, various receipts and other data are collected via B04. The Transaction Reporting program provides the means of loading the MDF data observations "buckets" for:

1) cumulative recurring demand units
2) cumulative recurring demand frequency
3) cumulative nonrecurring demand units
4) cumulative units of depot level repairable not-ready-for-issue (failed) carcasses returned to the wholesale system for eventual repair
5) production leadtime cumulative days and cumulative number of observations
6) procurement leadtime cumulative days and cumulative number of observations
7) carcasses in the repair process at a depot in cumulative units-weighted days and cumulative units undergoing repair
8) cumulative units which are disposed as a result of failure to survive the depot level repair process.

It should be noted that the cumulative units undergoing repair and the cumulative units disposed lead to an observation of the repair survival rate, which will be discussed later.

These data observations and how they are utilized in the Cyclic Forecasting and Levels program will be discussed in the FORECASTING section of this presentation.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

DATA COLLECTION SYSTEM

- o MASTER DATA FILE "BUCKETS" FOR OBSERVATIONS
  - oo BY LINE ITEM
  - oo DATA ELEMENTS

A004A	CURRENT SYSTEM RECURRING DEMAND FREQUENCY
A005	CURRENT SYSTEM RECURRING MAINTENANCE DEMAND
A005A	CURRENT SYSTEM RECURRING OVERHAUL DEMAND
A005B	CURRENT SYSTEM MAINTENANCE CARCASS RETURNS
A005C	CURRENT SYSTEM OVERHAUL CARCASS RETURNS
A006	CURRENT SYSTEM NONRECURRING DEMAND
B010G	CUMULATIVE PRODUCTION LEADTIME OBSERVATIONS
B010G	PRODUCTION LEADTIME OBSERVATIONS FREQUENCY
B011G	CUMULATIVE PROCUREMENT LEADTIME OBSERVATIONS
B011H	PROCUREMENT LEADTIME OBSERVATIONS FREQUENCY
B012G	CUMULATIVE REPORTING REPAIR IN PROCESS TIME OBSERVATIONS
B012H	CUMULATIVE QUANTITY REPAIRED AT REPORTING ACTIVITIES
B012K	CUMULATIVE NONREPORTING REPAIR TAT OBSERVATION
B012L	CUMULATIVE QUANTITY REPAIRED AT REPORTING ACTIVITIES

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

DATA COLLECTION SYSTEM

- MASTER DATA FILE "BUCKETS" FOR OBSERVATIONS (CONTINUED)

  F009D CUMULATIVE REPAIR INDUCTION QUANTITY

  F009E CUMULATIVE DISPOSAL QUANTITY

  F009D AND F009E ARE USED TO DETERMINE THE REPAIR SURVIVAL RATE

Slide #5 & 6

DATA COLLECTION SYSTEM

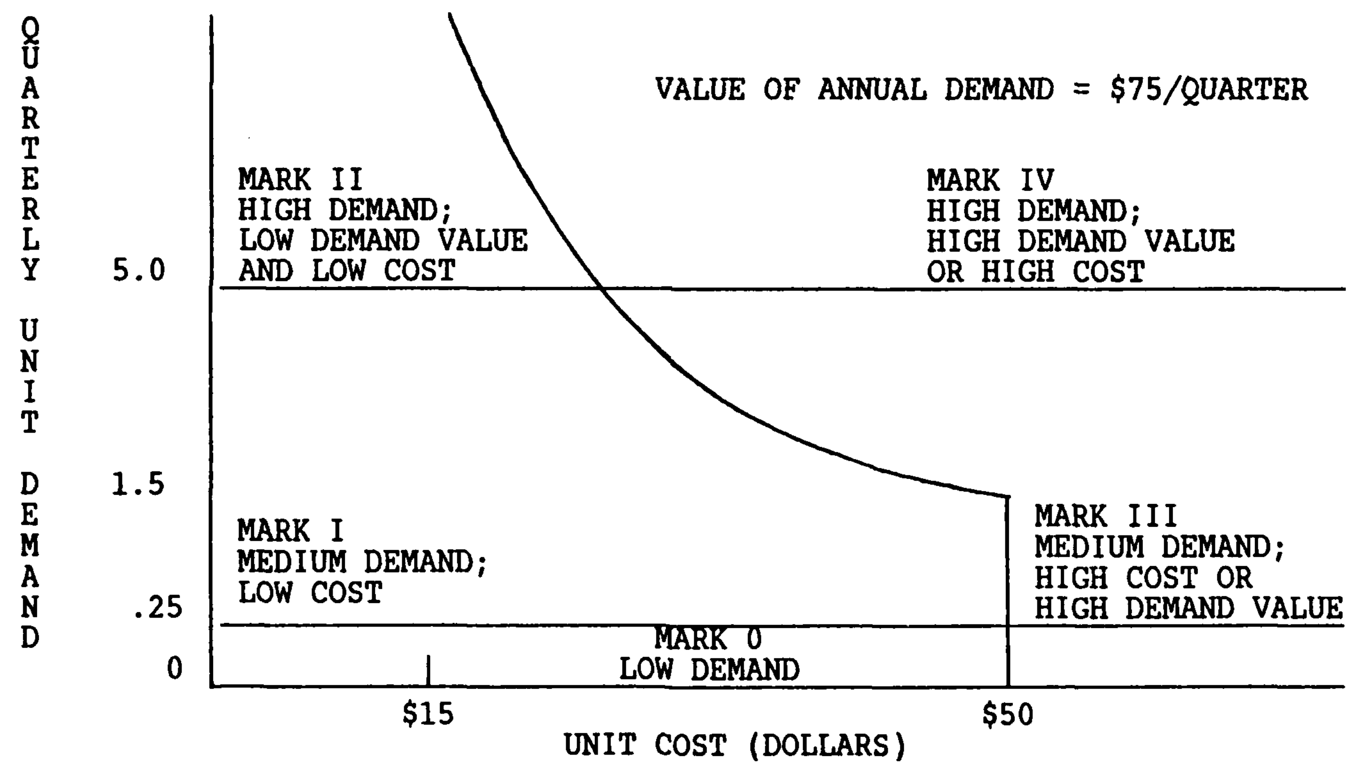
(Continued)

C. Master Data File (MDF)

As mentioned earlier, a MDF record exists for each Navy-managed NIIN. That record contains many data elements reflecting quantified characteristics associated with each NIIN. The data elements reflected here are those associated with observations used in computing forecasts to be used in determining wholesale inventory levels. The distinguishing feature between maintenance and overhaul observations is the Project Code on the requisition or carcass return document. A Project Code of "705" on a requisition indicates the material is associated with an overhaul program.

FORECASTING

- MARK SYSTEM FOR CATEGORIZING ITEMS



Slide #7

FORECASTING

A. MARK System

Before commencing discussion of the details of forecasting, it is important that the categorization items used by Navy is understood. The system shown here was developed prior to UICP (early 1960's) and has continued in existence through today. The primary factors involved in the categorization are units of quarterly recurring demand average forecast, unit replacement cost and dollar value of quarterly recurring demand average forecast.

In practice, there are "buffer zones" around each boundary to help minimize the number of Mark migrations by limiting the migrations to only significant changes in the primary factors. For simplicity, only the basic boundaries are shown here.

Note that the Low Demand -- Mark 0 -- items have only a quarterly recurring demand (units) forecast criterion; cost is not a factor in categorizing items as Mark 0.

How these Marks come into play in the forecasting routines will be discussed later in this section.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

- o GENERAL
  - oo MECHANIZED FORECASTING DONE IN UICP PROGRAM D01
  - oo MECHANIZED FORECASTING COMPLETED QUARTERLY
    - AVERAGES (MEANS)
    - MEAN ABSOLUTE DEVIATIONS
  - oo RECOMPUTED FORECASTS COMPLETED AS TRIGGERED BY ITEM MANAGER TO CORRECT ERRONEOUS DATA ELEMENTS
  - oo BASIC FORECASTING TECHNIQUES
    - EXPONENTIAL SMOOTHING; MOVING AVERAGE FOR PROGRAM RELATED ELEMENTS; POWER RULE
  - oo FILTERS TO DETECT ABNORMAL OBSERVATION
  - oo TEST FOR TRENDING
    - MORE RAPID SHIFTING OF AVERAGE (MEAN)

Slide #8

FORECASTING
(Continued)

B. General

The forecasting of data elements used in setting inventory levels is done in the UICP Cyclic Levels and Forecasting program (D01) and the resulting forecasts are loaded into the MDF records. This mechanized forecasting routine is done quarterly (1 September, 1 December, 1 March and 1 June), and the averages (means) and Mean Absolute Deviations (MADs) of most random variables are computed. More concerning each random variable's forecasts will be discussed later.

In addition to the mechanized forecasting routine, forecasts may be changed by the item managers (IMs) to correct erroneous data elements. The IM has the option of changing forecasts by direct input to the MDF record via the UICP batch program for Files Maintenance (C10) or the online program for Files Maintenance (PTEM) or indirectly via the Levels Recomputation program (part of D01) which will recompute new inventory levels for budget execution, based on the IM's forecasts, as well as update the MDF record.

Slide #8 (Continued)

FORECASTING

(Continued)

In the forecasting routines, the basic formulation involves single exponential smoothing and exponential power rules for nonprogram related items. For program related items, the basic formulation involves a moving average over a four quarters time base. In addition, there are filters to detect abnormally large or small observations so the the forecasting routine will either ignore such observations or require the IM to validate the observations prior to use in forecasting.

There are also tests for trending of demand observations and carcass returns observations. These tests are made to insure the forecasting routine properly reacts to shifts in the average (mean) of the underlying processes.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

- o GENERAL (CONTINUED)
  - oo FORECASTS USED FOR MANY PURPOSES

    SETTING BUDGET EXECUTION LEVELS IN UICP D01

    SETTING BUDGET FORMULATION LEVELS AND SIMULATING BUDGET FORMULATION REQUIREMENTS IN STRAT UICP B20

    ANALYSIS OF SUPPLY PERFORMANCE FOR VARIOUS INPUT PARAMETERS IN CARES ANALYZER

Slide #9

FORECASTING
(Continued)

The forecasts computed by the Cyclic Forecasting and Levels progam (D01) are used for several purposes; among which are:

1) inventory levels for budget execution
2) inventory levels for budget formulation
3) projecting inventory control performance for various input levels parameters (e.g., shortage costs, risk constraints, probability distributions, etc.)

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

- o RECURRING DEMAND AND CARCASS RETURNS (NONPROGRAM RELATED ITEMS)
  - oo MEAN ABSOLUTE DEVIATIONS NOT CALCULATED FOR MARK 0, I, III CONSUMABLES
  - oo FILTERS ON OBSERVATIONS

    LIMITS ON ACCEPTABLE OBSERVATIONS FOR REPAIRABLES AND MARK II/IV CONSUMABLES

    OLD AVERAGE FORECAST ± (1.25)(OLD MAD FORECAST)(V008)

    (1.25)(OLD MAD FORECAST) = STANDARD DEVIATION
    V008 = NUMBER OF STANDARD DEVIATIONS

    LIMITS ON ACCEPTABLE OBSERVATIONS FOR MARK 0, I AND III CONSUMABLES

    MAXIMUM {V008, 3 (OLD AVERAGE FORECAST}

    IF OBSERVATION IS WITHIN FILTER LIMITS, NORMAL FORECASTING RULES APPLY

    IF OBSERVATION IS OUTSIDE FILTER LIMITS:

    NO FORECASTS ARE COMPUTED IF FIRST TIME

    IF TWO SUCCESSIVE QUARTERS (BOTH HIGH OR BOTH LOW):

Slide #10

FORECASTING

(Continued)

C. Recurring Demand and Carcass Returns

This discussion will center on forecasting of non-program related items. Forecasting for program related items will be discussed later under the PROGRAM DATA section.

Mean Absolute Deviations (MADs) for recurring demand and carcass (failed depot level repairable) returns are not forecast for Mark 0, I and III consumable items. This is apparently due to the theory that observations of those random variables for such items occur so infrequently that the MADs cannot be accurately forecasted. Instead, the variance of leadtime demand is forecasted directly via an exponential power rule (to be discussed later). MADs are computed for all repairable and Mark II and IV consumable items.

The observations of recurring demand and carcass returns are filtered to eliminate abnormally high or low observations from the forecasting routine. Basically, the filter for repairable and for Mark II and IV consumable items is to compare the observation to the old forecasted average (mean) to see if it lies within a specified number of standard deviations of the mean. From a theoretical viewpoint, the assumption of standard deviation equal to (1.25 X MAD) implies an underlying normal distribution. V008 the acceptable number of standard deviations is set at 6.0 at SPCC and 3.0 at ASO. Since there are no

Slide #10 (Continued)

FORECASTING
(Continued)

MADs calculated for Mark 0,I, and III consumable items, the limit is set at the maximum of 3 times the mean (average) or an ICP set parameter, V008A (set at 2.0 at SPCC and 15.0 at ASO). By implication, the lower bound on Mark 0, I and III consumable items is zero.

If the observation is within the filter limits, the observation is accepted for forecasting. If the observation is outside the filter limits, other checks are made. If this is the first time (in succession) that an abnormal observation occurs, no new forecasts are computed; the old forecasts remain in effect. If the observations and the preceeding quarterly observation are both abnormally high or abnormally low,

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

NEW AVERAGE FORECAST = 0.5 (SUM LAST TWO OBS.)

NEW MAD FORECAST = $(V004)(\text{NEW AVE. FORECAST})^{V005} + V007$
FOR REPAIRABLE AND MARK II/IV CONSUMABLE ITEMS

oo TRENDING TEST

$$T = \frac{2(\text{SUM OF LAST TWO OBSERVATIONS})}{(\text{SUM OF LAST FOUR OBSERVATIONS})}$$

TRENDING CHECK:

UPWARD TREND IF $T \geq V272$ AND (LAST OBS.) $\geq$ (OLD AVE. FORE.)

DOWNWARD TREND IF $T \leq V272A$ AND (LAST OBS.) $\leq$ (OLD AVE. FORE.)

IF TRENDING, CHANGE NORMAL FORECASTING ROUTINE SMOOTHING WEIGHT α

Slide #11

FORECASTING
(Continued)

the filtering routine assumes there is a significant shift in the underlying process, computes a new average (mean) forecast as one-half the sum of the last two quarterly observations and computes a new MAD forecast in accordance with the exponential power rule shown here. Values for the ICP-controlled parameters V004, MAD forecast recomputation coefficient; V005, MAD forecast recomputation power; V007, MAD forecast recomputation additive factor are:

	V004	V005	V007
ASO	1.518	0.817	0
SPCC	1.370	0.717	0

In addition to checking for abnormal observations, the program also checks to determine trends -- shifts of the mean (average) value of the random variable distribution. This trend check applies to only Mark II and Mark IV items -- both repairable and consumable items. The check begins by computing the ratio of the sum of the last two quarterly observations doubled and the sum of the last four quarterly observations. If the ratio is larger than or equal to an ICP-set parameter (V272) and the last quarterly observation is larger than or equal to the old average forecast, the exponential smoothing weight is increased. Similarly, if the ratio is smaller than or equal to an ICP-set parameter (V272A) and the last quarterly observation is smaller than or equal to the old forecast, the exponential smoothing weight is increased.

Current Values:

	V272	V272A
ASO	1.50	0.99
SPCC	1.10	0.90

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

- NORMAL FORECASTING ROUTINE RULES: EXPONENTIAL SMOOTHING

  NEW AVERAGE FORECAST = (α)(OBSERVATION) + (1-α)(OLD AVERAGE FORECAST)

  DEMAND UNITS: B022 = (α)(A005 + A005A) + (1-α)(B022)
  B022 = RECURRING DEMAND AVERAGE
  B023D = B022 = QTRLY RECURRING DEMAND AT END OF LT

  CARCASS RETURNS: B022B = (α)(A005B + A005C) + (1-α)(B022B)

  REQN FREQUENCY: A023B = α(A004A) + (1-α)(A023B)

  MEAN ABSOLUTE DEVIATION FOR REPAIRABLE AND MARK II AND IV CONSUMABLE ITEMS

  NEW MAD FORECAST = (α)(|OBS - OLD AVE. FORE.|) + (1-α)(OLD MAD FORE.)

  DEMAND UNITS: A019 = α(|A005 + A005A - B022|) + (1-α)(A019)
  A019 = RECURRING DEMAND MAD

  CARCASS RETURNS: A019B = α(|A005B + A005C - B022B|) = (1-α)(A019B)

- α - VALUES
  = V273 FOR TRENDING MARK II AND IV ITEMS
  = V273A FOR TRENDING MARK 0, I, III ITEMS
  = V273B FOR ALL OTHER ITEMS

Slide #12

FORECASTING
(Continued)

The normal forecasting routine for nonprogram related items is single exponential smoothing. Simply put, the new average forecast is equal to the smoothing weight (α) times the last quarterly observation, plus one minus the smoothing weight times the old average forecast. We will see later a moving average technique is used for program related items. The formulas shown here reflect the UICP data elements used in computing the average forecasts for the various demand and carcass returns random variables.

The mean absolute deviation forecasts, as mentioned before, for these random variables are computed via single exponential smoothing for nonprogram related repairable and Mark II and Mark IV consumable items. Basically, the new MAD forecast is equal to the smoothing weight times the absolute value of the difference between the last quarterly observation and the old average forecast, plus one minus the smoothing weight times the old MAD forecast. The formulas shown here reflect the UICP data elements used in computing the MAD forecasts for the various demand and carcass returns random variables.

As mentioned before, the smoothing weight (α) values are increased when a trending condition is detected. The ICPs control the values of the smoothing weights. Current smoothing weight values at the ICPs for V273, for trending Mark II and IV items; V273A, for trending Mark 0, I and III items; and V273B, for nontrending items are:

	V273	V273A	V273B
ASO	0.40	0.40	0.20
SPCC	0.30	0.30	0.10

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

- o PRODUCTION (PLT) AND PROCUREMENT (PCLT) LEADTIMES
  - oo OBSERVATION COLLECTION

$① \longrightarrow ② \longrightarrow ③$

①	②	③
BUY GENERATION UICP B10/F01	CONTRACT AWARD UICP F02	FIRST RECEIPT BY ACTIVITY UICP B04

PROCUREMENT LEADTIME OBSERVATION = ③ - ① IN DAYS

PRODUCTION LEADTIME OBSERVATION = ③ - ② IN DAYS

ADMINISTRATIVE LEADTIME NOT OBSERVED DIRECTLY;
IMPLIED FROM [③ - ①]-[③ - ②]

  - oo FILTERS FOR ABNORMAL OBSERVATIONS

PRODUCTION: (V166)(OLD AVE PLT FORE)<(OBS)<(V165)(OLD AVE PLT FORE)

PROCUREMENT: (V164)(OLD AVE PCLT FORE)<(OBS)<(V163)(OLD AVE. PCLT FORE)

IF OBSERVATION IS OUTSIDE FILTER BAND, ITEM MANAGER MUST VALIDATE BEFORE ACCEPTANCE

Slide #13

FORECASTING
(Continued)

D. *Production and Procurement Leadtimes*

The leadtime observations for all items are collected as they occur and are used in forecasting at the end of the quarter they are collected. There are two leadtime observations collected -- a production leadtime observation and a procurement leadtime observation. The procurement leadtime is composed of administrative leadtime plus production leadtime; however, administrative leadtime observations are not collected. Basically, the production and procurement leadtime observations are collected as shown pictorially here. When a buy is generated mechanically by the UICP Supply Demand Review program (B10) or manually via the UICP Purchase program (F01), the date is entered in an online UICP file -- called the DDF (Due In/Due Out File). After the administrative process (technical screens, bids solicitation, etc.) is completed, a contract is awarded and that date is also entered in the DDF by the Purchase program (F02). Finally, when material is received into the wholesale system, the receiving activities transaction report the receipt to ICP. The date of the first receipt at an activity is loaded into DDF by the Transaction Reporting program (B04). At that point in time, the Transaction Reporting program calculates a production leadtime observation by comparing the two dates labelled 3 and 2 shown here and calculates a procurement leadtime obser-

Slide #13 (Continued)

FORECASTING
(Continued)

vation by comparing the two dates labelled 3 and 1 shown here. By implication, an administrative leadtime observation would be the difference between the procurement and production leadtime observations.

The observations of procurement and production leadtimes as calculated are then subjected to filters by the Transaction Reporting program to detect abnormal observations requiring manual validation prior to use in forecasting averages and MADs. *The filters for procurement and for production* leadtime observations are basically the same. Do the observations lie sufficiently close to the old average forecast to be accepted without validation? Sufficiently close is measured as percentages (V163, V164, V165, V166) of the old average forecasts, as shown here. Observations automatically accepted by the program or validated by the item manager and reentered into the program are collected in the UICP Master Data File "buckets" for that quarter.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

- OBSERVATIONS COLLECTED

  CUMULATIVE DAYS: B011G, PROCUREMENT: B011G, PRODUCTION
  OBSERVATION FREQUENCY: B011H, PROCUREMENT: B010H, PRODUCTION

- QUARTERLY OBSERVATION COMPUTED

  PROCUREMENT: (B011G) + (B011H X 91)
  PRODUCTION: (B010G) + (B010H X 91)

- NORMAL FORECASTING ROUTINE: EXPONENTIAL SMOOTHING

  NEW AVE. FORECAST = α(QTRLY OBSERVATION) + (1-α)(OLD AVE. FORECAST)

  PROCUREMENT: B011A = α(QTRLY OBS) + (1-α)(B011A)
  PRODUCTION: B010 = α(QTRLY OBS) + (1-α)(B010)

  MEAN ABSOLUTE DEVIATION OF PROCUREMENT LEADTIME IF $\alpha \neq$ 1 OR 0

  NEW MAD FORECAST = α(|QTRLY OBS - OLD AVE FORE|)+(1-α)(OLD MAD FORE)
  B011B = α(|QTRLY OBS - B011A|) + (1-α)(B011B)

Slide #14

FORECASTING
(Continued)

The observations (measured in days) are cumulatively summed in the data element B011G "bucket" for procurement leadtime observations and in the B010G "bucket" for production leadtime observations. In addition, each time an observation is cumulated in B011G and B010G the respective frequency "buckets" -- B011H and B010H -- are incremented by one.

At the end of each quarter, the UCIP Cyclic Forecasting and Levels program (D01) computes a quarterly observation and reforecasts new average and MAD forecasts. The quarterly observation is simply the cumulative observations (B011G or B010G value) divided by the cumulative observations frequency (B011H or B010H value, respectively), converted from days to quarters. The forecasting is then done via single exponential smoothing routines very similar to those used for demands and carcass returns.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

MEAN ABSOLUTE DEVIATION OF PROCUREMENT LEADTIME IF $\alpha = 1$ OR 0

NEW MAD FORECAST = A (NEW AVE. FORECAST)^{B}

B011B = V067(B011A)^{V068}

oo α- VALUE DEPENDENT ON LENGTH OF TIME SINCE LAST OBSERVATION

IF 1st OR 2nd PAST QUARTER, α = V194, PROCUREMENT
= V197, PRODUCTION

IF 3rd OR 4th PAST QUARTER, α = V195, PROCUREMENT
= V198, PRODUCTION

IF PRIOR TO 4th QUARTER, α = V196, PROCUREMENT
= V199, PRODUCTION

Slide #15

FORECASTING
(Continued)

The major differences are in the assignment of smoothing weight values and computation of a new MAD forecast via an exponential power rule if the smoothing weight is zero or one. The smoothing weights are dependent upon the length of time since the last recorded observation.

Current ICP controlled values for the parameters shown here are:

		ASO	SPCC
Procurement leadtime MAD recomputation coefficient	V067	0.80	0.051
Procurement leadtime MAD reomputation power	V068	0.50	0.884
Procurement leadtime α, last observation 1st or 2nd past quarter	V194	0.5	0.2
Procurement leadtime α, last observation 3rd or 4th past quarter	V195	0.5	0.5
Procurement leadtime α, last observation 5th or more past quarter	V196	0.5	1.0
Production leadtime α, last observation 1st or 2nd past quarter	V197	0.5	0.2
Production leadtime α, last observation 3rd or 4th past quarter	V198	0.5	0.5
Production leadtime α, last observation 5th or more past quarter	V199	0.5	1.0

Slide #15 (Continued)

FORECASTING
(Continued)

It should be noted that there are certain problems in forecasting procurement and production leadtimes as shown. These problems will be discussed more fully in the section entitled PROBLEM AREAS IN IMPLEMENTATION AND USE OF MODELS, but briefly they are:

(1) After the fact forecasting:
   (a) Slow to react to rapid changes in either administrative or production leadtimes.
   (b) Forecasting of administrative leadtime must wait until production leadtime is observed.

(2) Procurement and production leadtimes are forecasted independently:
   (a) Filters may require item manager (IM) to validate a procurement leadtime observation but not the associated production leadtime observation (or vice versa); if the IM does not validate, the two forecasts may get out of synch so that administrative leadtime is not properly represented by the difference of the two forecasts.
   (b) Production leadtime average forecast can equal or exceed the procurement leadtime average forecast, implying a zero or a negative administrative leadtime average.

These problems must be overcome by IM manual intervention. Efforts are underway to correct these program deficiencies.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

o REPAIR IN PROCESS TIMES AND REPAIR TURNAROUND TIMES

oo OBSERVATION COLLECTION

CONDITION CODE "M" TO CONDITION CODE "A"

EXCLUDES TIME IN CONDITION CODES "D" AND "G"

oo FILTERS FOR ABNORMAL OBSERVATIONS

NONREPORTING: (V168)(OLD AVE. INPROCESS FORE.)<(OBS)< (V167)(OLD AVE. INPROCESS FORE.)

REPORTING: (V170)(OLD AVE. INPROCESS FORE.)<(OBS)< (V169)(OLD AVE. INPROCESS FORE.)

IF OBSERVATION IS OUTSIDE FILTER BAND, ITEM MANAGER MUST VALIDATE BEFORE ACCEPTANCE

oo OBSERVATIONS COLLECTED

CUMULATIVE QUANTITY-WEIGHTED DAYS: B012G, REPORTING
B012K, NONREPORTING

CUMULATIVE QUANTITY: B012H, REPORTING
B012L, NONREPORTING

Slide #16

FORECASTING
(Continued)

E. Repair Inprocess Times and Repair Turnaround Times

The objective in this forecasting process is to arrive at forecasts for repair cycle time and depot level turnaround time -- the two random variables which are used in setting inventory levels for procurement and repair of depot level repairables.

A brief description of the cycle of a depot level repairable is as follows: (1) a depot level repairable component fails during operation, (2) the customer requisitions a ready-for-issue component from the supply system and turns the failed unit (carcass) into the wholesale supply system (this period from failure to turn in could be lengthy if the customer is operating in a remote geographical location), (3) the wholesale stock point transaction reports the receipt of the not-ready-for-issue carcass to the ICP, (4) the ICP determines a need to repair the carcass at a Navy or commercial depot, (5) the ICP issues an order to move the carcass from the wholesale stock point to the depot and an order for the depot to induct the carcass into repair, (6) the depot receives the carcass and inducts it into the repair process, (7) the depot completes repairs and moves the repaired unit to the wholesale supply

FORECASTING
(Continued)

system, (8) the receiving wholesale stock point transaction reports receipt of the ready-for-issue unit.

The first step in the forecasting process is the collection of repair inprocess time observations. This represents the time the item is reported to the ICP as undergoing repair. That is, the time the item is in "M" condition. When the ICP issues the order to the depot to repair a carcass, that date of that order is loaded into the DDF. When the depot (if transaction reporter) or the stock point (if the depot is not a transaction reporter) reports a movement of the carcass to "M" condition, that date is loaded into the UICP Due-In/Due-Out File (DDF). When the repaired unit is reported to the ICP in "A" condition, that date is entered in the DDF. The time from "M" to "A" condition is the in-process time observation in days. The in-process time observation for repair at a nonreporting depot accounts for the time of shipment of the carcass from a reporting activity until receipt of the repaired unit at a reporting activity. Whereas, if repair is accomplished at a reporting depot, the in-process time observation accounts for only the time the carcass is actually under repair.

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Slide #16 (Continued)

FORECASTING
(Continued)

As with the leadtime observations, the inprocess time observations are filtered to detect abnormal observations requiring item manager validation prior to acceptance. Current ICP values for the parameters are:

		ASO	SPCC
Reporting activity in-process time high value filter multiplier	V167	2.00	2.00
Reporting activity in-process time low value filter multiplier	V168	0.10	0.25
Nonreporting activity in-process time high value filter multiplier	V169	2.00	2.00
Nonreporting activity in-process time low value filter multiplier	V170	0.10	0.25

The collection of cumulative time observations in UICP Master Data File "buckets" is in quantity-weighted days. For example, if the observation indicates four units were repaired in 30 days, the cumulative values collected would be 120 unit-days in data element B012G (if the repair was done at a reporting activity) or in data element B012K (if the repair was not done at a reporting activity) and four units in data element B012H or B012L respectively.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

oo QUANTITY-WEIGHTED QUARTERLY OBSERVATION

$$\sum_{\text{INDUCTIONS}} (\text{QUANTITY X REPAIR TIME})_I \div \sum_{\text{INDUCTIONS}} (\text{QUANTITY})_I \text{ X } 91$$

REPORTING: QUARTERLY OBSERVATION = (B012G) ÷ (B012H X 91)

NONREPORTING: QUARTERLY OBSERVATION = (B012K) ÷ (B012L X 91)

Slide #17

FORECASTING

(Continued)

During the quarterly Cyclic Forecasting and Levels program operation, the average quarterly quantity-weighted observation is calculated and converted from days to quarters as shown here, which is simply the cumulative quantity-weighted time value divided by the cumulative quantity value.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

oo NORMAL FORECASTING ROUTINE: EXPONENTIAL SMOOTHING

NEW AVE. FORECAST + α(QTRLY OBSERVATION) + (1-α)(OLD AVE. FORECAST)

REPORTING: B012 = α(QTRLY OBSERVATION) + (1-α)(B012C)
NONREPORTING: B012 = α(QTRLY OBSERVATION) + (1-α)(B012)

MEAN ABSOLUTE DEVIATION IF $\alpha \neq$ 1 OR 0

NEW MAD FORECAST = α(|QTRLY OBS-OLD AVE FORE|) + (1-α)(OLD MAD FORE)

REPORTING: B012D = α(|QTRLY OBS-B012C|) + (1-α)(B012D)
NONREPORTING: B012B = α(|QTRLY OBS-B012|) + (1-α)(B012B)

MEAN ABSOLUTE DEVIATION IF α = 1 OR 0

NEW MAD FORECAST = A (NEW AVE. FORECAST)^{B}

REPORTING: B012D = V062(B012C)^{V063}
NONREPORTING: B012B = V062(B012)^{V063}

Slide #18

FORECASTING
(Continued)

As with the leadtime forecasts, the repair inprocess times are forecasted using exponential smoothing. However, the Mean Absolute Deviation (MAD) is forecast using an exponential power rule if the smoothing weight value is one or zero. The smoothing weight value is dependent upon the time elapsed since the last observation, similar to that of leadtime forecasting. Current ICP-controlled parameter values are:

		ASO	SPCC
In-process time MAD forecast recomputation coefficient	V062	0.800	0.051
In-process time MAD forecast recomputation power	V063	0.500	0.884

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

oo α - VALUE DEPENDENT ON LENGTH OF TIME SINCE LAST OBSERVATION

IF 1st OR 2nd PAST QUARTER, α = V200, REPORTING
= V203, NONREPORTING

IF 3rd OR 4th PAST QUARTER, α = V201, REPORTING
= V204, NONREPORTING

IF PRIOR TO 4th QUARTER, α = V202, REPORTING
= V205, NONREPORTING

Slide #19

FORECASTING
(Continued)

Other ICP-Controlled parameter values are:

		ASO	SPCC
Reporting activity in-process time smoothing weight, last observation 1st of 2nd quarter past	V200	0.30	0.20
Reporting activity in-process time smoothing weight, last observation 3rd or 4th quarter past	V201	0.30	0.50
Reporting activity in-process time smoothing weight, last observation 5th or more quarter past	V202	0.30	1.00
Nonreporting activity in-process time smoothing weight, last observation 1st or 2nd quarter past	V203	0.20	0.20
Nonreporting activity in-process time smoothing weight, last observation 3rd or 4th quarter past	V204	0.10	0.50
Nonreporting activity in-process time smoothing weight, last observation 5th or more quarter past	V205	0.30	1.00

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

- o DEPOT LEVEL TURNAROUND TIME
  - oo ELEMENTS

    SHIPMENT TIME FROM NON-REPAIR POINT TO REPAIR POINT
    ICP ADMINISTRATIVE TIME TO PREPARE REPAIR SCHEDULE
    TIME FROM ISSUANCE OF REPAIR SCHEDULE TO INDUCTION
    TIME FROM INDCUTION AT REPAIR POINT UNTIL PICKUP IN "A" CONDITION

  - oo FORMULAS FOR AVERAGE FORECAST

    REPORTING: B012C + V294 + V070 + (V039/2) = B012E
    NONREPORTING: B012 + (V039/2) = B012E

  - oo FORMULAS FOR VARIANCE FORECAST

    REPORTING: $(1.25\ B012D)^2 + V189$
    NONREPORTING: $(1.25\ B012B)^2$

- o REPAIR CYCLE TIME
  - oo ELEMENTS

    DEPOT LEVEL TURNAROUND TIME
    TIME INTERVAL BETWEEN RUNNING OF REPAIR SCHEDULES

Slide #20

FORECASTING
(Continued)

The inprocess time forecasts are the primary ingredient in developing the forecasts for depot level turnaround time and repair cycle time, which are in turn used in computing inventory levels (order quantity, reorder point, repair quantity and repair point).

As defined in budget development terminology in the early 1970's, depot level turnaround time is composed of the elements shown here. Navy's UICP formulas were developed in the late 1960's. Since that definition was promulgated, Navy has not altered the UICP formulas for depot level turnaround time average forecast (data element B012E) or for the variance forecast. The ICPs have utilized the ICP-controlled parameters of the original UICP formulas to attempt to conform with the definition. Current ICP parameter values are:

	V189	V070	V039
ASO	31 Days	14 Days	0.077
SPCC	30 Days	0	0

In budget development terminology, repair cycle time is the sum of the depot level turnaround time and the interval between repair schedule determinations.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

oo FORMULAS FOR AVERAGE FORECAST

REPORTING: MIN (B011A; V057; B012C + V294 + V040) = B012F

NONREPORTING: MIN (B011A; V057; B012 + V040) = B012F

oo FORMULA FOR VARIANCE FORECAST

(DEPOT LEVEL TAT VARIANCE FORECAST) + V040 + $\frac{Q_2 - 1}{B}$

Slide #21

FORECASTING
(Continued)

Again, the original UICP formulas have not been changed; the ICPs have utilized the existing ICP-controlled parameters in an attempt to conform with the definition. Current ICP parameter values are:

	V057	V040
ASO	2.00	0.154
SPCC	10.00	0

Note: There are constraints on the repair cycle time average fcrecast (data element B012F) so that the value in B012F will not exceed the procurement average forecast (data element B011A) or an ICP-set parameter.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

- o REPAIR SURVIVAL RATE
  - oo DECIMAL VALUE BETWEEN 0 AND 1
  - oo OBSERVATIONS COLLECTED

    CUMULATIVE REPAIR INDUCTION QUANTITY (F009D)
    CUMULATIVE REPAIR DISPOSAL QUANTITY (F009E)

  - oo OBSERVATION OF SURVIVAL RATE

$$\frac{\text{CUM REPAIR INDUCTION QTY} - \text{CUM REPAIR DISPOSAL QTY}}{\text{CUM REPAIR INDUCTION QTY}}$$

$$(\text{F009D} - \text{F009E}) \div \text{F009D}$$

  - oo NORMAL FORECASTING ROUTINE: EXPONENTIAL SMOOTHING

$$\text{NEW AVE. FORECAST} + \alpha(\text{SURVIVAL RATE OBS}) + (1-\alpha)(\text{OLD AVE. FORE.})$$

$$\text{F009} = \text{V206}(\text{SURVIVAL RATE OBS}) + (1-\text{V206})(\text{F009})$$

$$\text{NEW MAD FORECAST} = \alpha(|\text{SURV RATE OBS}-\text{SURV RATE AVE}|)+(1-\alpha)(\text{OLD MAD FORE})$$

$$\text{F009A} = \text{V206}\ (|\text{SURV RATE OBS}-\text{F009}|)+(1-\text{V206})(\text{F009A})$$

Slide #22

FORECASTING
(Continued)

F. Repair Survival Rate

The repair survival rate is a random variable representing the percentage of carcasses inducted into the repair process which survive and are returned to the wholesale supply system in ready-for-issue condition. Since this is a percentage, its value lies between zero and one. When the depot doing repair inducts a batch of carcasses, the Master Data File record for the NIIN is updated to reflect the cumulative quantity for that quarter inducted to the repair process; that data is loaded into UICP data element F009D. Upon completion of the repair process, the quantity which does not survive the repair process is reported to the ICP and is loaded into the cumulative UICP data element F009E.

The quarterly observation of the repair survival rate which is used in forecasting is computed by the Cyclic Forecasting and Levels program as shown here.

The average and MAD forecasts are computed using the same single exponential smoothing process we have looked at before.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

<u>FORECASTING</u>

oo ITEM MANAGER MAY SUPPRESS FORECASTING

OLD FORECASTS REMAIN

NEGOTIATED CONTRACTS

Slide #23

FORECASTING
(Continued)

It should be noted that the item manager does have the option of suppressing the computation of repair survival rate forecasts if he has reason to believe they should remain into the foreseeable future. An example is when the ICP has negotiated a contract with a depot (in house Navy or commercial) to complete repairs within specified repair inprocess times and at greater than or equal specified survival rates.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

FORECASTING

- o MANUAL FILE MAINTENANCE CHANGES BY ITEM MANAGERS
  - oo DIRECT DATA ELEMENT UPDATE
    - UICP PROGRAM C10 (BATCH) OR PTEM (ONLINE)
    - ONLY INPUT DATA LEMENT UPDATED
  - oo RECOMPUTATION UPDATE
    - UICP PROGRAM D01
    - INPUT DATA ELEMENT UPDATED
    - ASSOCIATED DATA ELEMENTS RECOMPUTED
      - MEAN ABSOLUTE DEVIATION: POWER RULE
      - OTHER LEVELS DATA ELEMENTS
    - REORDER (REPAIR) POINT AND ORDER (REPAIR) QUANTITY RECOMPUTED

Slide #24

FORECASTING
(Continued)

G. Manual File Maintenance

The item manager (IM) may override the forecasts computed by the Cyclic Forecasting and Levels program. The IM may accomplish the override actions by two mechanized processes. First, if the IM desires to change the value of a data element but does not desire to alter the previously-set inventory levels at that time, the IM submits an update action via UICP batch Files Maintenance program (C10). On the other hand, if the IM desires to recompute inventory levels as well as change the value of an average forecast, the IM will submit an update action via a special routine in UICP program D01 -- the Cyclic Forecasting and Levels program -- for batch processing or via an online Files Maintenance program (PTEM) which also feeds input to UICP program D01. That process will also recompute the MAD, of the random variable which the IM is updating the average forecast, via an exponential power rule similar to those we have seen earlier in this presentation and will use the new forecasts in the recomputation of the inventory levels.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

REQUIREMENTS DETERMINATION

FORMULAS DERIVATION

o CONSUMABLES: PROCUREMENT

oo BASIS IS TOTAL VARIABLE COST EQUATION OF DODI 4140.39, MODIFIED TO ELIMINATE SUMMATIONS, INCLUDE A BACKORDER TERM IN HOLDING COST AND CONFORM WITH DATA COLLECTION SYSTEM

$$TVC = \frac{4D(A+A')}{Q} + IC\left(R + \frac{Q}{2} - \mu + \frac{1}{Q}\int_R^{\infty}(X-R)[F(X+Q)-F(X)]dx\right)$$
$$+ \frac{\lambda FE}{DQ}\int_R^{\infty}(X-R)[F(X+Q)-F(X)]dx$$

ALL SYMBOLS SAME AS DODI 4140.39, EXCEPT

4D = ANNUAL RECURRING DEMAND AVERAGE FORECAST

= 4 (B023D)

A' = MANUFACTURER'S SETUP COST = B058

S = REQUISITION SIZE = $\frac{D}{F} = \frac{\text{B023D}}{\text{A023B}} = \frac{\text{RECURRING DMD AVE.}}{\text{REQN FREQ. AVE.}}$

μ = (PROCUREMENT LEADTIME AVE FORECAST)X(RECURRING DEMAND AVE FORE)

= (B011A) X (B023D)

Slide #25

REQUIREMENTS DETERMINATION FORMULAS DERIVATION

A. Consumables: Procurement

The basis for the basic formulas used in computing inventory levels (order quantity, reorder point) for the procurement of consumables is the total variable cost (TVC) equation of DODI 4140.39. However, the basic formula of DODI 4140.39 has been modified by eliminating the summations, by including the number of backorders at any random point in time in the holding cost term, and using symbols representing data elements which conform to the UICP data collection system. In examining the TVC equation shown here, you will note the following:

(1) The forecast of average annual recurring demand is assumed to be four times the forecast of average quarterly recurring demand.

(2) The manufacturer's set-up cost may be included in the *order cost* term.

(3) The average requisition size forecast (S in DODI 4140.39 formula) is assumed to be equal to the recurring demand average forecast divided by the recurring requisition frequency average forecast.

(4) "μ" is equal to the procurement leadtime average forecast times the recurring demand average forecast since observations of leadtime demand are not collected.

REQUIREMENTS DETERMINATION

FORMULAS DERIVATION

- oo SOLUTION IS DERIVED BY TAKING PARTIAL DERIVATIVES WITH RESPECT TO Q AND R AND SETTING PARTIALS EQUAL TO ZERO

$$Q = \sqrt{\frac{8D(A+A')}{IC} + \left(2+\frac{\lambda FE}{DIC}\right)\int_{R}^{\infty}(x-R)[F(X+Q)-F(X)]dx}$$

$$\frac{1}{Q}\int_{R}^{\infty}[F(X+Q)-F(X)]dx = \frac{DIC}{DIC+\lambda FE} = P_{OUT}$$

- oo APPROXIMATIONS IMPOSED DUE COMPLEXITY OF SOLUTION

$$Q = \sqrt{\frac{8D(A+A')}{IC}} = \sqrt{\frac{8(B023D)(B058+ICP\ ADMIN\ COST)}{(HOLDING\ RATE)(B055)}}$$

ICP ADMIN COST: V015, MARK I AND II ITEMS
V041, SMALL PURCHASE
V042, NEGOTIATED
V043, ADVERTISED

Slide #26

REQUIREMENTS DETERMINATION FORMULAS DERIVATION

(Continued)

The first step to minimize the TVC equation is to take the partial derivatives with respect to Q and R and set the partials equal to zero. As shown here, the solution at this point is a cumbersome coupling of the order quantity (Q) and the reorder point (R). Due to the difficulties imposed by implementing the exact solution derived here or alternatively using a search technique to arrive at an optional Q and R for each item, Navy made two approximations.

The first approximation was to shorten the formula for Q to the relatively simple Wilson EOQ formula. This approximation implicitly assumes the order quantity and/or safety level is large enough so that the backorder term is negligible. The approximation also uncouples the reorder point (R) from the order quantity formula. The ICP administrative costs depend on the Mark of the item and the method of contracting to be used. The Mark I and II items since they are the cheap items are assumed to always be small purchase (less than $10,000 per contract per Armed Service Procurement Regulations) and the administrative cost is represented by ICP-controlled parameter V015. The other administrative costs breakout are:

(1) other items for small purchase procedures (parameter V041),

(2) items requiring negotiated contracts (parameter V042),

(3) items requiring advertised contracts (parameter V043)

Current ICP-set values are:

	V015	V041	V042	V043
ASO	123.09	123.09	206.68	206.68
SPCC	155.00	155.00	450.00	500.00

REQUIREMENTS DETERMINATION FORMULAS DERIVATION

HOLDING RATE: SUM OF V101, TIME REFERENCE RATE;
B057, OBSOLESCENCE RATE;
STORAGE RATE OF 0.01

$$\text{RISK} = \frac{\text{DIC}}{\text{DIC}+\lambda\text{FE}}$$

RISK TRANSLATES TO REORDER POINT. RISK IS AREA UNDER THE RIGHT TAIL OF THE LEADTIME DEMAND PROBABILITY DISTRIBUTION CURVE.

Slide #27

REQUIREMENTS DETERMINATION FORMULAS DERIVATION
(Continued)

The holding cost rate used in these formulas is composed of three elements: (1) the time preference rate (parameter V101) provided to the ICPs by Naval Supply Systems Command; (2) the obsolescence cost rate (data element B057) which may be an item unique data element and (3) the storage cost rate set at 0.01. The current value of B057 for consumable items is 0.12. The current value of V101 is 0.10.

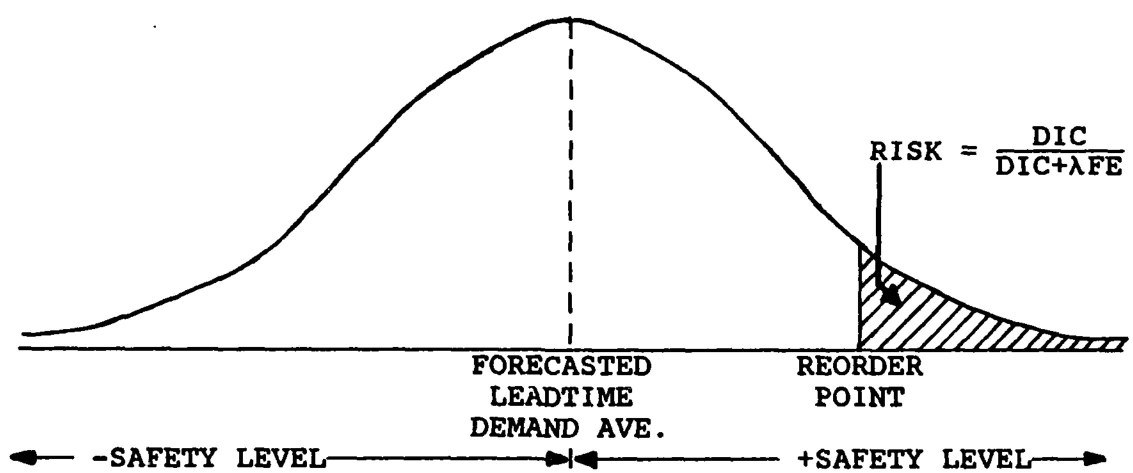
The solution for the partial derivative with respect to R results in a formula for the probability of being out of stock at a random point in time which is called P_{out} by Hadley and Whitin in Analysis of Inventory Systems. Navy has approximated by setting the economic formula to RISK rather than P_{out}. RISK is defined as the probability of being out of stock in an order cycle. The reorder point is derived from RISK.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

REQUIREMENTS DETERMINATION

FORMULAS DERIVATION

oo TRANSPOSING RISK TO REORDER POINT (NORMAL DISTRIBUTION)



oo ORDER QUANTITY PRICE BREAK COMPUTATIONS TO BE DISCUSSED IN REPAIRABLES: PROCUREMENT SECTION

Slide #28

REQUIREMENTS DETERMINATION FORMULAS DERIVATION
(Continued)

Pictorially the RISK may be shown as the area under the right tail of the leadtime demand probability distribution. As shown here for a normal distribution, the RISK as computed from the economic formula is translated to the reorder point by establishing the number of standard deviations the reorder point should be from the average leadtime demand; thus the safety level. In the example shown, the RISK results in a positive safety level.

It can be shown mathematically that RISK is greater than or equal to P_{out}. Therefore, the accuracy of the reorder point approximation computed via RISK depends on how closely RISK = P_{out} as well as how closely the Wilson EOQ equals the optional Q equation shown above. Of course, the minimization of the DODI 4140.39 TVC equation may be invalidated by an active constraint on the order quantity size or safety level size, as imposed by DODI 4140.39 or Navy implementation constraints.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

REQUIREMENTS DETERMINATION FORMULAS DERIVATION

- o REPAIRABLES: PROCUREMENT

  - oo BASIS IS A REQUISITIONS - SHORT TOTAL VARIABLE COST EQUATION. WAS MODEL FOR CONSUMABLES PRIOR TO DODI 4140.39

$$TVC = \frac{4(D-B)(A+A')}{Q} + IC\left|R + \frac{Q}{2} - \mu + \int_R^\infty (X-R)f(x)dx\right| + \frac{\lambda 4(D-B)EF}{QD}\int_R^\infty (x-R)f(x)dx$$

ALL SYMBOLS SAME AS DODI 4140.39 AND FOR CONSUMABLES, EXCEPT

B = READY-FOR-ISSUE REPAIR REGENERATIONS AVERAGE FORECAST

= B023F

f(x) = LEADTIME DEMAND PROBABILITY FUNCTION

4(D-B) = ANNUAL ATTRITION RECURRING DEMAND AVERAGE FORECAST

μ = (PROCUREMENT LEADTIME AVE. FORECAST)x(ATTRITION RECURRING DEMAND AVE. FORECAST)+(REPAIR CYCLE TIME)x(READY-FOR-ISSUE REPAIR REGENERATIONS AVE. FORECAST)

= (B011A)(B023D-B023F)+(B012F)(B023F)

Slide #29

REQUIREMENTS DETERMINATION FORMULAS DERIVATION
(Continued)

B. Repairables: Procurement

The basis for the basic formulas used in computing inventory levels for the procurement of repairables is a TVC equation somewhat similar to the model of DODI 4140.39. This model was developed several years prior to DODI 4140.39 and was used for Navy-managed consumables, as well as repairables, until DODI 4140.39 was implemented for consumables. The model is a requisitions-short model rather than a time-weighted requisitions-short model. The model incorporates the features of:

(1) Attrition demand; the gross recurring demand (units) less the ready-for-issue units from repair of not-ready-for-issue carcasses returned to the wholesale system.
(2) Repair Cycle Time discussed before in the FORECASTING section.
(3) Expected number of units short in an order cycle -- the integral.

Note: The expected units backordered at a random point in time, in the holding cost term, is approximated by the expected number of units backordered in an order cycle.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

REQUIREMENTS DETERMINATION FORMULAS DERIVATION

- oo SOLUTION IS DERIVED BY TAKING PARTIAL DERIVATIVES WITH RESPECT TO Q AND R AND SETTING PARTIALS EQUAL TO ZERO

$$Q = \sqrt{\frac{8(D-B)(A+A')}{IC} + \left|\frac{8\lambda(D-B)EF}{ICD}\right| \int_R^{\infty}(x-R)f(x)dx}$$

$$\int_R^{\infty} f(x)dx = \frac{QICD}{QICD=4\lambda FE(D-B)} = \text{RISK}$$

- oo APPROXIMATION IMPOSED

$$Q = \sqrt{\frac{8(D-B)(A+A')}{IC}} = \sqrt{\frac{8(\text{B023D}-\text{B023F})(\text{B058}+\text{ICP ADMIN COST})}{(\text{HOLDING RATE})(\text{B055})}}$$

ICP ADMIN COST:	V041, SMALL PURCHASE V042, NEGOTIATED V043, ADVERTISED
HOLDING RATE:	V101A, TIME PREFERENCE RATE B057, OBSOLESCENCE RATE STORAGE RATE OF 0.01

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REQUIREMENTS DETERMINATION FORMULAS DERIVATION
(Continued)

The solution is derived in a manner similar to that of the DODI 4140.39 solution for consumables. That is, taking the partial derivatives of the TVC equation with respect to Q and R and setting the partials to zero. The results are a cumbersome coupling of Q and R involving integrals shown here.

As with the solution to DODI 4140.39, Navy has elected to use an approximate solution for the order quantity Q. The approximateion is the familiar Wilson EOQ formula.

Note: This formula involves a parameter for the time preference rate for repairables, which may be set at a different value than the time preference rate for consumables.

Current values used by the ICPs are:

	ASO	SPCC
V101A	0.10	0.10

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

REQUIREMENTS DETERMINATION

FORMULAS DERIVATION

oo REORDER POINT CALCULATED FROM RISK

Slide #31

REQUIREMENTS DETERMINATION FORMULAS DERIVATION

(Continued)

The reorder point calculation utilizes the RISK methodology discussed before.

REQUIREMENTS DETERMINATION FORMULAS DERIVATION

- o REPAIRABLES: REPAIR

  - oo BASIS IS A REQUISITIONS-SHORT TOTAL VARIABLE COST EVALUATION

$$TVC = \frac{4MIN(D;B)(A_2+A'_2)}{Q_2} + I_2C_2\left(R_2 + \frac{Q_2}{2} - \mu + \int_{R_2}^{\infty}(X-R_2)f(x)dx\right) + \frac{\lambda_2 4MIN(D;B)EF}{DQ_2}\int_{R_2}^{\infty}(x-R_2)f(x)dx$$

ALL SYMBOLS SAME AS DODI 4140.39 AND FOR CONSUMABLES AND REPAIRABLES, EXCEPT:

Q_2	=	REPAIR QUANTITY
R_2	=	REPAIR POINT
C_2	=	REPAIR COST = B055A
$f(x)$	=	*PROBABILITY FUNCTION OF DEPOT LEVEL* TURNAROUND TIME DEMAND
λ_2	=	REPAIR SHORTAGE COST = V107
A_2	=	ICP REPAIR SETUP COST = V016
A'_2	=	DEPOT REPAIR SETUP COST = B058A
μ	=	(DEPOT LEVEL TAT AVE)(RECURRING DEMAND AVE)
	=	(B012E)(B022)

Slide #32

REQUIREMENTS DETERMINATION FORMULAS DERIVATION

(Continued)

C. Repairables: Repair

The basis for the basic formulas for computing inventory levels for the repair of repairables is the requisitions - short TVC model described here. As seen, this model is quite similar to the other two models examined previously, except this model utilizes parameters and random variables which are appropriate to solving the repair problem of inventory management:

(1) MIN (D;B) is apparently utilized to apply whichever random variable becomes the constraining factor. If for some reason Ready-for-Issue (RFI) regenerations (B) are higher than recurring demand (D), there is no need to repair more than the recurring demand (if levels are full). On the other hand is D>B, one cannot expect to repair more than B no matter how large the D. Shortages due to RFI regeneration shortfall to recurring demand must be made up through procurement.

(2) I_2, λ_2, A_2, and A_2' are parameters related to the repair process.

(3) Q_2 and R_2 are the repair quantity and repair point -- equivalents to the order quantity and the reorder point of the procurement problem.

(4) Instead of the leadtime demand as in the procurement problem, the repair problem concerns the depot level turnaround time (TAT) demand.

(5) C_2 is the cost to have one unit of an item repaired.

(6) The integral represents the number of units short in a repair cycle--equivalent to the number of units short in an order cycle in the procurement problem.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

REQUIREMENTS DETERMINATION FORMULAS DERIVATION

I_2 = HOLDING RATE: TIME PREF. RATE = V108
OBSOLESCENCE RATE = B057
STORAGE RATE = 0.01

- oo SOLUTION DERIVED BY TAKING THE PARTIAL DERIVATIVES WITH RESPECT TO Q_2 AND R_2 AND SETTING PARTIALS EQUAL TO ZERO
- oo APPROXIMATIONS IMPOSED DUE TO COMPLEXITY OF SOLUTION

$$Q_2 = \sqrt{\frac{8\ \mathrm{MIN}(D;B)(A_2+A_2')}{I_2 C_2}}$$

$$\mathrm{RISK}_2 = \frac{Q_2 I_2 D_2}{Q_2 I_2 C_2 + 4\lambda_2 FBE}$$

- oo REPAIR LEVEL DERIVED FROM RISK_2, SIMILAR TO HOW REORDER POINT DERIVED FROM RISK

- o LEADTIME DEMAND VARIANCE FOR CONSUMABLES
  - oo BASIS IS THAT PROCUREMENT LEADTIMES AND RECURRING DEMANDS ARE INDEPENDENT RANDOM VARIABLES

Slide #33

REQUIREMENTS DETERMINATION FORMULAS DERIVATION
(Continued)

The solution to minimizing this TVC equation is derived in a manner similar to those discussed in the procurement problem of consumables and repairables. That is, the partial derivatives of the TVC with respect to Q_2 and R_2 are set to zero and approximations are imposed. Those approximations are shown here; the symbols used have been described before.

The current values of the repair time preference rate:

	ASO	SPCC
V108	0.10	0.10

D. Leadtime Demand Variance for Consumables

The variances of leadtime demand are very important in computing the magnitude of the procurement safety level. Now the procedures for computing the leadtime demand variance for consumables will be examined.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

REQUIREMENTS DETERMINATION FORMULAS DERIVATION

oo LEADTIME DEMAND RANDOM VARIABLE EXPRESSION

$$Z = \sum_{i=1}^{L} D_i$$

WHERE LEADTIME AND RECURRING DEMAND OBSERVATIONS ARE ASSUMED TO BE MUTUALLY INDEPENDENT AND IDENTICALLY DISTRIBUTED

oo VARIANCE DERIVATION SOLUTION (PARZEN, STOCHASTIC PROCESSES)

$$\text{VAR }(Z) = \bar{L}\text{ VAR }(D) + \bar{D}^2\text{ VAR }(L) = \text{B019A}$$

o LEADTIME DEMAND VARIANCE FOR REPAIRABLES

oo BASIS IS THAT PROCUREMENT LEADTIMES, RECURRING DEMANDS, READY-FOR-ISSUE REGENERATIONS AND REPAIR CYCLE TIMES ARE INDEPENDENT RANDOM VARIABLES

oo LEADTIME DEMAND RANDOM VARIABLE EXPRESSION

$$\sum_{i=1}^{L} D_i - \sum_{i=1}^{L} B_i + \sum_{i=1}^{T} B_i$$

Slide #34

REQUIREMENTS DETERMINATION FORMULAS DERIVATION
(Continued)

As was briefly indicated during the discussion in the FORECASTING, leadtime demands are not observed. Rather, observations of procurement leadtimes are collected, and observations of recurring demand are collected. The underlying computation of leadtime demand forecasts assumes the two random variables are independent--which appears to be a reasonable assumption. Under that assumption, the leadtime demand random variable may be expressed as the sum of independent and identically distributed observations. From the summation, the variance of leadtime demand can be derived as shown here. For those so inclined to derive the solution, the reference is Parzen's Stochastic Processes page 56.

E. Leadtime Demand Variance for Repairables

When leadtime demand for a repairable is considered, there are several random variables involved:

(1) Procurement leadtime
(2) Repair cycle time
(3) Recurring demands
(4) Ready-for-issue regenerations (combination of carcass returns and survival rate)

Again the random variables are assumed to be independently distributed random variables so that the leadtime demand can be expressed as the summation shown here.

REQUIREMENTS DETERMINATION FORMULAS DERIVATION

WHERE OBSERVATIONS OF THE RANDOM VARIABLES ARE ASSUMED TO BE MUTUALLY INDEPENDENT AND IDENTICALLY DISTRIBUTED
$B = (C) \times (S)$, WHERE C = CARCASS RETURNS AND S = SURVIVAL RATE

- oo VARIANCE DERIVATION SOLUTION (PARZEN, STOCHASTIC PROCESSES)

$$\mathrm{VAR}\ (Z) = (\overline{L}-\overline{T})[\mathrm{VAR}\ (D) + \overline{C}^2\ \mathrm{VAR}\ (S) + \overline{S}^2\ \mathrm{VAR}\ (C) + \mathrm{VAR}\ (C)\ \mathrm{VAR}\ (S)] + (\overline{D} - \overline{C}\ \overline{S})^2\ [\mathrm{VAR}\ (L) + \mathrm{VAR}\ (T)] + \overline{T}\ \mathrm{VAR}\ (D) + \overline{D}^2\ \mathrm{VAR}\ (T) = \mathrm{B019A}$$

- o DEPOT LEVEL TURNAROUND TIME DEMAND VARIANCE FOR REPAIRABLES
  - oo BASIS IS THAT DEPOT LEVEL TURNAROUND TIMES AND RECURRING DEMANDS ARE INDEPENDENT RANDOM VARIABLES
  - oo DEPOT LEVEL TURNAROUND TIME DEMAND RANDOM VARIABLE EXPRESSION

$$Z_2 = \sum_{i=1}^{T^2} D_i$$

WHERE TURNAROUND TIME AND RECURRING DEMAND OBSERVATIONS ARE ASSUMED TO BE MUTUALLY INDEPENDENT AND IDENTICALLY DISTRIBUTED

  - oo VARIANCE DERIVATION SOLUTION (PARZEN, STOCHASTIC PROCESSES)

$$\mathrm{VAR}\ (Z_2) = \overline{T}_2\ \mathrm{VAR}\ (D) + \overline{D}^2\ \mathrm{VAR}\ (T_2) = \mathrm{B019C}$$

Slide #35

REQUIREMENTS DETERMINATION FORMULAS DERIVATION
(Continued)

And again, using the technique described in Parzen, the long formula for the variance of leadtime demand, shown here, can be derived.

F. Depot Level Turnaround Time Demand Variance

In a manner similar to the procurement leadtime variance formula derivation for consumables, the variance of depot level turnaround time demand for depot level repairables can be derived.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PROGRAM DATA

- o ASO
  - oo PROGRAM DATA ELEMENTS
    - MAINTENANCE CYCLES (100 FLYING HOURS)
    - NUMBER OF OVERHAULS OF END ITEM
  - oo APPLICABLE ITEMS
    - ALL REPAIRABLES EXCEPT THOSE ON GROUND SUPPORT EQUIPMENT
    - ALL CONSUMABLES DURING DEMAND DEVELOPMENT INTERVAL (PHASE-IN)
    - OTHER CONSUMABLE ITEMS FOR SELECTED WEAPON SYSTEMS
    - INVESTIGATING USE ON CONSUMABLE ITEMS DURING PHASE-OUT
  - oo ITEMS IDENTIFIED VIA UICP DATA ELEMENT B067E
  - oo PROGRAM PLANNING DATA PROVIDED BY CNO, NAVAIR, USAF
    - FLYING HOURS BY AIRCRAFT TYPE (E.G. F4J)
    - NO. OF OVERHAULS BY END ITEM (E.G. TF41 ENGINE)
    - PLANNING DATA UP TO 20 QUARTERS INTO FUTURE, PLUS MOBILIZATION AND RETENTION
    - ACTUAL DATA BY MONTH AFTER OCCURRENCE

Slide #36

PROGRAM DATA

The use of program data relationships in forecasting for VSL levels requirements computation is currently limited to the Aviation Supply Office (ASO). The Ship Parts Control Center (SPCC) is currently studying the feasibility of using population data as a program data element in forecasting for the VSL/EOQ/ERQ levels.

A. ASO

At ASO, there are basically two types of program data elements--maintenance cycles (there are 100 flying hours per maintenance cycle) and the number of overhauls of an end item (engine, equipments, components, etc.)

At ASO, those program elements are used in recurring demand and ready-for-issue regeneration forecasting for all repairable items (except those applicable to ground support equipment); all consumable items during the phase-in (or demand development interval); and consumables applicable to certain, selected weapon systems. In addition, ASO is currently investigating the use of program data for consumable items during weapon system phase-out.

The Cyclic Forecasting and Levels program (UICP program D01) identifies items, requiring forecasts to be computed using program data, by keying on whether the program relationship indicator (UICP data element B067E) is set.

Slide #36 (Continued)

PROGRAM DATA

The program data information utilized by ASO comes from various sources. The flying hour data comes from the Chief of Naval Operations (CNO) and Air Force; while overhaul data comes from Naval Air Systems Command (NAVAIR) and ASO itself. Flying hours are expressed by aircraft type while overhauls are linked to the end item.

Program data is usually provided 3 times per year and includes information up to 20 quarters into the future, plus planning information for mobilization and retention. Actual occurrence data is provided to ASO monthly immediately after occurrence.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PROGRAM DATA

- oo PROGRAM EXPANDED FROM AIRCRAFT OR END ITEM DOWN TO APPLICABLE LINE ITEMS VIA SUBASSEMBLY BREAKDOWNS

- o SPCC
  - oo NO PROGRAM DATA CURRENTLY USED IN VSL FORECASTING; ALL ITEMS NONPROGRAM RELATED
  - oo INVESTIGATING FEASIBILITY OF USING POPULATION CHANGES IN VSL FORECASTING
  - oo POPULATION IS USED AS PROGRAM DATA ELEMENT IN PROVISIONING PORCESS AND IN INCREASING ASSETS FOR SELECTED ESSENTIAL WEAPON SYSTEMS

Slide #37

PROGRAM DATA
(Continued)

The program data is linked to NIINs by breaking down the aircraft type or end item through its subassemblies to the applicable line items so that program data expansion may be expressed as:

Cycles Per Aircraft X No. of System A Per Aircraft X % of Aircraft with System A X No. of Subsystem B Per System A X % of System A With Subsystem B X

No. of Assembly C Per Subsystem B X % of Subsystem B with Assembly C X No. of NIIN Z Per Subassembly Y X % of Subassembly Y With NIIN Z

B. SPCC

Population is used as a program data element to compute wholesale and retail buy requirements during the provisioning process--initial provisioning plus follow-on buys during the demand development interval. At SPCC, currently program data is not used in forecasting computations associated with UICP VSL/EOQ/ERQ inventory levels. However, SPCC is testing the feasibility of using population data, particularly during weapon system phase-in. This procedure is in its early stages and has not been applied to all weapon systems.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PROGRAM DATA

- o CAPABILITY FOR FORECASTING RECURRING DEMAND
  - oo MAINTENANCE RECURRING DEMAND AVERAGE (B022) FOR CONSUMABLE ITEMS

$$\text{B022} = \frac{\text{SUM OF LAST 4 QUARTERS MAIN. DEMAND OBSERVATIONS}}{\text{SUM OF LAST 4 QUARTERS MAIN. PROGRAM VALUES}}$$

  - oo MAINTENANCE RECURRING DEMAND AVERAGE (B022) FOR REPAIRABLE ITEMS

$$\text{B022} = \frac{\text{SUM OF LAST 4 QUARTERS MAIN. AND OVERHAUL DMD. OBSERVATIONS}}{\text{SUM OF LAST 4 QUARTERS MAIN. PROGRAM VALUES}}$$

  - oo MAINTENANCE RECURRING DEMAND MEAN ABSOLUTE DEVIATION (A019) FOR MARK II AND MARK IV CONSUMABLE ITEMS

$$\text{A019} = \frac{\sum \left| \text{B022} - \dfrac{\text{MAIN. DMD OBSERVATION}}{\text{MAIN. PROGRAM VALUE}} \right|}{4}$$

WHERE $\sum$ IS FOR LAST 4 QUARTERS

Slide #38

PROGRAM DATA
(Continued)

C. Capability for Forecasting Recurring Demand

The remaining portion of this PROGRAM DATA section is devoted to the mathematical formulas used in forecasting and using program data in UICP.

The maintenance recurring demand average is an average rate per program element. It is a moving average: the sum of the last four quarters observations divided by the sum of the last four quarters maintenance program values. It is to be noted that for repairable items, maintenance and overhaul observations are combined so that in effect there is only a maintenance program for repairables. Similarly, for program-related Mark II and IV items, the mean absolute deviation is computed as a moving average over the past four quarters.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PROGRAM DATA

- oo MAINTENANCE RECURRING DEMAND MEAN ABSOLUTE DEVIATION (A019) FOR MARK II AND MARK IV REPAIRABLE ITEMS

$$\text{A019} = \frac{\sum \left| \text{B022} - \dfrac{\text{SUM OF MAIN. AND OVERHAUL DMD OBSERVATIONS}}{\text{MAIN. PROGRAM VALUE}} \right|}{4}$$

WHERE $\sum$ IS FOR LAST 4 QUARTERS

- oo OVERHAUL RECURRING DEMAND AVERAGE (B022A) FOR CONSUMABLE ITEMS ONLY

$$\text{B022A} = \frac{\text{SUM OF LAST FOUR QUARTERS OVERHAUL DEMAND OBSERVATIONS}}{\text{SUM OF LAST FOUR QUARTERS PROGRAM VALUES}}$$

- oo OVERHAUL RECURRING DEMAND MEAN ABSOLUTE DEVIATION (A019A) FOR MARK II AND MARK IV CONSUMABLE ITEMS ONLY

$$\text{A019} = \frac{\sum \left| \text{B022} - \dfrac{\text{OVERHAUL DEMAND OBSERVATION}}{\text{OVERHAUL PROGRAM VALUE}} \right|}{4}$$

WHERE $\sum$ IS FOR LAST 4 QUARTERS

- oo MAINTENANCE PROGRAM FOR YEAR AT END OF PROCUREMENT LEADTIME (B077B)

$$\text{B077B} = \sum_{t = \bar{L} + 1}^{\bar{L} + 4} (\text{MAIN. PROGRAM VALUE})_t$$

WHERE $\bar{L}$ = PROCUREMENT LEADTIME AVERAGE = B011A

Slide #39

PROGRAM DATA
(Continued)

In a manner similar to the maintenance program, values for overhaul recurring demand averages (data element B022A) and mean absolute deviation (data element A019A) are computed for consumable items.

In preparing to compute the average recurring demand forecasts over various periods of time, it is necessary that the program values for those time periods be computed. The formulas for the program values for those time periods are shown here:

Maintenance Program for Year at End of Procurement Leadtime (data element B077B). Note: if procurement leadtime (L) is a decimal value, L is truncated to a whole number. This program value is used in determining the order quantity.

PROGRAM DATA

oo OVERHAUL PROGRAM FOR YEAR AT END OF PROCUREMENT LEADTIME (B077C)

$$B077C = \sum_{t = \bar{L} + 1}^{\bar{L} + 4} (\text{OVERHAUL PROGRAM VALUE})t$$

oo RECURRING DEMAND AVERAGE FORECAST AT TEND OF LEADTIME (B023D)

$$B023D = \frac{(B022)(B077B) + (B022A)(B077C)}{4}$$

oo MAINTENANCE PROGRAM DURING PROCUREMENT LEADTIME (B077)

$$B077 = \sum_{t = 1}^{\bar{L}} (\text{MAINTENANCE PROGRAM VALUE})_t$$

oo OVERHAUL PROGRAM DURING PROCUREMENT LEADTIME (B077A)

$$B077 = \sum_{t = 1}^{\bar{L}} (\text{OVERHAUL PROGRAM VALUE})_t$$

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PROGRAM DATA
(Continued)

Overhaul Program for Year at End of Procurement Leadtime (data element B077C). This program value is used in computing the recurring demand forecast to be used in computing the order quantity.

Recurring Demand Average Forecast at End of Leadtime (data element B023D). This is the demand forecast used in computing the order quantity.

Maintenance Program During Procurement Leadtime (data element B077). This program value is used in computing the recurring demand forecast to be used in computing the reorder point.

Overhaul Program During Procurement Leadtime (data element B077A). This program value is used in computing the recurring demand forecast to be used in computing the reorder point.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PROGRAM DATA

- oo RECURRING DEMAND AVERAGE DURING PROCUREMENT LEADTIME (B023C)

$$B023C = (B022)(B077) + (B022A)(B077A)$$

- oo MAINTENANCE PROGRAM DURING DEPOT LEVEL TURNAROUND TIME (B077E)

$$B077E = \sum_{t=1}^{\overline{T}_2} (\text{MAINTENANCE PROGRAM VALUE})_t$$

- oo RECURRING DEMAND AVERAGE DURING DEPOT LEVEL TURNAROUND TIME (B023H)

$$B023H = (B022)(B077E)$$

- oo QUARTERLY RECURRING DEMAND AVERAGE FORECAST (B074)

$$B074 = \frac{B023C}{B011A}$$

- o CAPABILITY FOR FORECASTING READY-FOR-ISSUE REGENERATIONS

- oo CARCASS RETURN AVERAGE (B022B)

$$B022B = B022 \left(\frac{1 - F007}{F009} \right)$$

WHERE: F007 = WEAROUT RATE
F009 = REPAIR SURVIVAL RATE

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PROGRAM DATA
(Continued)

Recurring Demand Average During Procurement Leadtime (data element B023C). This is the recurring demand forecast used in computing the reorder point.

Maintenance Program During Depot Level Turnaround Time (data element B077E). This is the program value used in computing the recurring demand forecast to be used in computing the repair point.

Recurring Demand Average During Depot Level Turnaround Time (data element B023H). This is the recurring demand forecast used in computing the repair point.

Quarterly Recurring Demand Average Forecast (data element B074). This is simply the average quarterly program during the procurement leadtime multiplied by the recurring demand rate.

D. Capability for Forecasting RFI Regenerations

The Carcass Return Average (data element B022B)--a rate--is not computed from observations but rather is computed as a percentage of the recurring demand average--a rate. The percentage is the percent of recurring demand units which are expected to be returned to the wholesale supply system as carcasses. The *wearout rate* (F007) *represents* that percentage of not-ready-for-issue units which are not expected to survive the carcass return and repair processes.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PROGRAM DATA

- oo CARCASS RETURN ABSOLUTE DEVIATION (A019B)

$$A019B = A019 \left(\frac{1 - F007}{F009} \right)$$

- oo READY-FOR ISSUE REGENERATIONS AT END OF PROCUREMENT LEADTIME (B023F)

$$B023F = \frac{(F009)(B022B)(B077B)}{4}$$

- oo READY-FOR-ISSUE REGENERATIONS DURING PROCUREMENT LEADTIME (B023E)

$$B023E = (F009)(B022B)(B077)$$

- oo MAINTENANCE PROGRAM DURING REPAIR CYCLE TIME (B077D)

$$B077D = \sum_{t = \bar{L}}^{\bar{L} + \bar{T}} (\text{MAINTENANCE PROGRAM VALUE})_t$$

- oo READY-FOR-ISSUE REGENERATIONS DURING REPAIR CYCLE TIME (B023G)

$$B023G = (F009)(B022B)(B077D)$$

- oo QUARTERLY READY-FOR-ISSUE REGENERATIONS AVERAGE FORECAST (B074A)

$$B074A = \frac{B023E}{B011A}$$

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PROGRAM DATA
(Continued)

In a similar manner, the Carcass Return Absolute Deviation (data element A019B) is computed utilizing the Recurring Demand Mean Absolute Deviation (data element A019).

The RFI Regenerations at the End of Procurement Leadtime (data element B023F) is the carcass return average forecast times the survival rate average forecast (data element F009) times the average program during the year at end of procurement leadtime (data element B077B÷4).

The RFI Regenerations During Procurement Leadtime (data element B023E) is the carcass return average forecast (data element B022B) times the survival rate average forecast (data element F009) times the program during the average procurement leadtime (data element B077).

In the computation of the reorder point (leadtime demand average portion), it is necessary to compute the ready-for-issue regenerations average during the repair cycle time (data element B023G). To arrive at data element B023G, it is first necessary to compute the maintenance program during the repair cycle time (data element B077D), which is computed similarly to data element B077 (the program during procurement leadtime as shown here). Following that, data element B023G is computed in a manner similar to data element B023E above.

Finally the Quarterly Ready-for-Issue Regenerations Average Forecast (data element B074A) is computed similar to data element B074.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PROGRAM DATA

- o CAPABILITY FOR COMPUTING ORDER QUANTITY AND REPAIR QUANTITY ELEMENTS
  - oo B023D = RECURRING DEMAND AVERAGE AT END OF PROCUREMENT LEADTIME
  - oo B023F = RECURRING RFI REGEN. AVER. AT END OF PROCUREMENT LEADTIME
- o *CAPABILITY FOR COMPUTING* REORDER LEVEL ELEMENTS
  - oo PROCUREMENT LEADTIME DEMAND AVERAGE (Z)

$$B023C - B023E + B023G$$

  - oo AVERAGE MAINTENANCE PROGRAM PER QUARTER DURING LEADTIME ($\bar{P}_1$)

$$\bar{P}_1 = \frac{B077}{B011A}$$

  - oo AVERAGE OVERHAUL PROGRAM PER QUARTER DURING LEADTIME ($\bar{P}_2$)

$$\bar{P}_2 = \frac{B077A}{B011A}$$

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PROGRAM DATA
(Continued)

E. Capability for Computing Order Quantity and Repair Quantity

The values for the program related data elements B023D and B023F are utilized in the basic formulas and constraints discussed in the FORMULA DERIVATION and CONSTRAINTS/PARAMETERS sections, for the order quantity and the repair quantity.

F. Capability for Computing Reorder Levels

The procurement leadtime demand average for a program related item is the sum of the program related data elements shown here: procurement leadtime gross demand average (data element B023C), procurement leadtime RFI regenerations average (data element B023E) and depot level TAT RFI regenerations average (data element B023G).

A key element in the safety level computation is the procurement leadtime demand variance, which involves the average program values during the procurement leadtime. The average maintenance program per quarter and the average overhaul program per quarter are computed as shown here for P_1 and P_2.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PROGRAM DATA

oo PROCUREMENT LEADTIME DEMAND VARIANCE (B019A)

$$B019A = \bar{L}\ VAR(D) + (\bar{D} - \bar{C}\bar{S})^2\ VAR(L) + [(\bar{D} - \bar{C}\bar{S})^2 + \bar{D}^2]\ VAR(T) + (\bar{L} - \bar{T})\ [\bar{C}^2\ VAR(S) + \bar{S}^2\ VAR(C) + VAR(C)\ VAR(S)]$$

WHERE:

$\bar{L}$ = PROCUREMENT LEADTIME AVERAGE = B011A

$\bar{D}$ = QUARTERLY RECURRING DEMAND AVERAGE = B074 (PROGRAM RELATED)

$\bar{C}$ = CARCASS RETURN AVERAGE = B022B (PROGRAM RELATED)

$\bar{S}$ = REPAIR SURVIVAL RATE AVERAGE = F009

$\bar{T}$ = REPAIR CYCLE TIME AVERAGE = B012F

VAR(D) = RECURRING DEMAND VARIANCE = $(1.25)^2[(\bar{P}_1\ A019)^2 + (\bar{P}_2\ A019A)^2]$ (PROGRAM RELATED)

VAR(C) = CARCASS RETURNS VARIANCE = $(1.25)^2(A019B)^2$ (PROGRAM RELATED)

VAR(S) = REPAIR SURVIVAL RATE VARIANCE = $(1.25)^2(F009A)^2$

VAR(L) = PROCUREMENT LEADTIME VARIANCE = $(1.25)^2(B011B)^2$

VAR(T) = REPAIR CYCLE TIME VARIANCE

oo RISK FOR CONSUMABLE ITEMS

$$RISK_E = \frac{DIC}{DIC + \lambda FE}$$

WHERE: D = B023D (PROGRAM RELATED)

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PROGRAM DATA
(Continued)

As can be seen, the formula for the procurement leadtime variance is quite complicated, involving the program related averages and variances for the random variables of recurring demand and carcass returns.

The economic procurement RISK formulas ($RISK_E$) involve the program related average recurring demand (data element B023D) for consumables ...

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PROGRAM DATA

- oo RISK FOR REPAIRABLE ITEMS

  $$RISK_E = \frac{QIC\bar{D}}{QIC\bar{D} + 4\lambda FE(D-B)}$$

  WHERE: $\bar{D}$ = B074 (PROGRAM RELATED)
  D = B023D (PROGRAM RELATED)
  B = B023F (PROGRAM RELATED)

- oo CONSTRAINTS DISCUSSED IN NONPROGRAM RELATED SECTION APPLY

o CAPABILITY FOR COMPUTING REPAIR LEVEL ELEMENTS

- oo DEPOT LEVEL TURNAROUND TIME DEMAND AVERAGE = B023H (PROGRAM RELATED)
- oo DEPOT LEVEL TURNAROUND TIME DEMAND VARIANCE = B019C

  $$B019C = \bar{T}_2 \; VAR(D) + \bar{D}^2 \; VAR(T^2)$$

  WHERE: $\bar{T}_2$ = DEPOT LEVEL TURNAROUND TIME = B012E

  $\bar{D}$ = QUARTERLY RECURRING DEMAND AVERAGE = B074 (PROGRAM RELATED)

  VAR(D) = RECURRING DEMAND VARIANCE (PROGRAM RELATED)

  VAR(T_2) = DEPOT LEVEL TURNAROUND TIME VARIANCE

- oo $$RISK_{2E} = \frac{Q_2 I_2 C_2 \bar{D}}{Q_2 I_2 C_2 \bar{D} + 4\lambda_2 FEB}$$

  WHERE: $\bar{D}$ = B074 (PROGRAM RELATED)
  B = B023D (PROGRAM RELATED)

- oo CONSTRAINTS DISCUSSED IN NONPROGRAM RELATED SECTION APPLY

Slide #45

PROGRAM DATA
(Continued)

and data elements B023D, B074 and B023F for repairables.

Of course the RISK constraints discussed in the CONSTRAINTS/PARAMETERS section are applied to the economic risk derived from RISK values computed using program related data elements.

G. Capability for Computing Repair Levels

The repair point is the depot level TAT demand average (data element B023H)--which is program related--plus the safety level which is a function of the program-related depot level TAT demand variance (data element B019C). The variance computation involves the average and variance of the program related recurring demand forecasts.

Finally the economic repair risk involves the program related recurring demand averages, data elements B074 and B023D. The risk constraints on economic repair RISK discussed in the nonprogram related sections apply.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

ESSENTIALITY

- o SHORTAGE COST TERM OF VSL/EOQ/ERQ MODELS
  - oo SYSTEM HAS CAPABILITY FOR ESSENTIALITY VALUES FROM 0 TO 1
  - oo NAVY HAS NO CODING SYSTEM IN EFFECT
  - oo "E" SET TO FIXED VALUE FOR ALL ITEMS
    - UICP DATA ELEMENT C008C
    - SPCC VALUE SET AT 0.50
    - ASO VALUE SET AT 0.01
- o ESSENTIALITY IS USED IN VSL/EOQ/ERQ COMPUTATIONS
  - oo SEGREGATION OF ITEMS BY WEAPON SYSTEM TO ACHIEVE GOALS
    - NUCLEAR PROPULSION SUPPORT: 95% REQN FILL RATE
    - FBM WEAPON SYSTEM SUPPORT: 95% REQN FILL RATE
    - TRIDENT HULL SUPPORT: 90% REQN FILL RATE
    - BY AIRCRAFT SYSTEM: 85% REQN FILL RATE
  - oo FOUR-DIGIT COG CAPABILITY
    - LEVELS PARAMETERS BY SEGREGATION CATEGORIES
    - MILSTEP MONITORING BY SEGREGATION CATEGORIES

Slide #46

ESSENTIALITY

This section discusses the mechanized capability for handling essentiality coding in the VSL/EOQ/ERQ models and the extent to which essentiality is used at the Navy ICPs.

A. Shortage Cost Term

As we have seen in the economic procurement and repair risk formulas, the UICP programs have the capability to handle essentiality for computing inventory levels. By design, the UICP limits on acceptable numerical values for essentiality are 0 and 1.

Although the UCIP models have the capability to handle essentiality, a coding system to set values for use in the models has not been developed. Rather, the ICPs have arbitrarily set the essentiality data element (C008C) to a fixed value. At SPCC the value is 0.50 and at ASO it is 0.01.

B. Essentiality is Used in VSL/EOQ/ERQ Computations

Although the Navy ICPs have not implemented an essentiality coding system for use in the VSL/EOQ/ERQ models, they do utilize essentiality considerations in computing inventory levels. This is accomplished by segregating items by weapon systems of interest.

Slide #46 (Continued)

ESSENTIALITY
(Continued)

For example, Chief of Naval Operations (CNO) stated goals for requisition fill rates for various weapon systems are:

95% for nuclear propulsion support
95% for FBM weapon system support
90% for TRIDENT hull support
85% for other weapon systems support items

The concept is to segregate the items associated with weapon systems of interest into groups in order to achieve requisition fill rate goals. Those groups are called four-digit cogs in UICP-language. The UICP programs and files have been designed to recognize the distinct four-digit cogs and to allow the ICP to:

- Set different inventory level parameters by four-digit cog in order to achieve the supply support goals.
- Monitor progress in achieving those goals for the designated four-digit cogs through the UICP MILSTEP reporting program.

The higher requisition fill rate goals for certain weapon systems imply a higher essentiality for the items associated with those weapon systems. In addition due to the high unit cost of items on new aircraft, ASO (Aviation Supply Office) has found it necessary to establish an 85% goal to each weapon system (vice to the total of all items in the ASO universe) to insure "equal essentiality" of weapon systems.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

ESSENTIALITY

- o ADDITIONAL USES OF ESSENTIALITY
  - oo TRIDENT AND FBM SUBMARINES
    - SHIPBOARD ALLOWANCE LIST
    - MILITARY ESSENTIALITY CODING (1-116)
    - DEGREE OF PROTECTION DEPENDENT UPON MEC-VALUE
  - oo MINIMUM REORDER POINT LEVELS AT SPCC
    - NSO POLICY
    - VERY LOW DEMAND ITEMS
    - ITEMS WITH CASREPTS, ON ALLOWANCES OR CANNIBALIZED
  - oo ASO IS INVESTIGATING FEASIBILITY OF ESTABLISHING MINIMUM REORDER POINT LEVELS FOR VERY LOW DEMAND ITEMS WITH INCIDENCE OF NMCS/PMCS

Slide #47

ESSENTIALITY
(Continued)

C. Additional Uses of Essentiality

Essentiality is also a consideration in the development of allowance lists for TRIDENT and Fleet Ballistic Missile (FBM) submarines. Items utilized on those ships are given a military essentiality code (MEC) ranging between 1 and 116, depending on the relative worth to the operation and mission to the ship. Items with larger MEC values receive greater degree of protection against stock-out in the allowance quantity computations.

Also, essentiality is a consideration in the NSO (Numeric Stockage Objective) policy at SPCC. For items with very low demand forecasts and which would receive no or very small reorder points, SPCC has established minimum reorder points of a minimum replacement unit if the item is on a shipboard allowance list, failure has resulted in a CASREPT or in a cannabalization action.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

IMPLEMENTATION ASSUMPTIONS

- CONTINUOUS REVIEW SYSTEM
  - DAILY TRANSACTION REPORTING
  - DAILY REVIEW FOR PROCUREMENT AND REPAIR ACTIONS
- STEADY-STATE ENVIRONMENT
  - UNDERLYING DISTRIBUTIONS AND ASSOCIATED PARAMETERS (MEANS AND VARIANCES) DO NOT CHANGE BETWEEN FORECASTING INTERVALS
- ALL RANDOM VARIABLES ARE MUTUALLY INDEPENTENT, EXCEPT FOR UNIT COST-ORDER SIZE RELATIONSHIP
  - DEMANDS AND CARCASS RETURNS
  - ORDER QUANTITIES AND LEADTIMES
  - REPAIR QUANTITIES AND TURNAROUND TIMES
  - REPAIR COST AND REPAIR QUANTITY

Slide #48

IMPLEMENTATION ASSUMPTIONS

Basic assumptions in the implementation of VSL/EOQ/ERQ policy in UICP are shown here:

A. Continuous Review System

Assumption: the models operate in a continuous review system such that requirements and assets are continuously compared in order that procurement and repair actions are initiated precisely when the reorder and repair points are reached. In reality, assets are reported daily by the stock points to the ICP rather than as soon as they occur (batch processing rather than online processing).

Furthermore, since asset reporting is periodic rather than continuous, the comparison of assets and requirements--through the UICP programs Supply Demand Review (B10) for procurement and Repair Scheduling (B08) for repair--is also completed on a periodic basis. Since assets are only reported daily, it does not make sense to run those programs more often than once daily. However, due to ADP, funding or workload constraints, the programs are generally run less often than on a daily basis. Of course, the less frequently they are run, the greater the probability of stock-outs since the models are based on a continuous review system.

Slide #48 (Continued)

IMPLEMENTATION ASSUMPTIONS
(Continued)

B. Steady-State Environment

Assumption: the models operate in a steady-state environment. That is the underlying distributions of the primary random variables--demand, leadtimes, carcass returns, etc.--do not change during the forecasting horizon. In reality, the environment is anything but steady-state. Leadtimes increase significantly and rapidly if there are raw material shortages or the private sector demands saturate industrial capacity for a commodity or sole manufacturer. Changing tempo of fleet operations impact demand patterns. Other examples could be cited, but it is clearly evident that the environment is not at steady-state for any length of time.

C. Random Variable Independence

Assumption: all random variables observations are mutually independent of other random variable observations. This assumption is made primarily to ease computation, but it is recognized that the random variable relationships shown here are not likely to be completely independent across the range of possible values.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

IMPLEMENTATION ASSUMPTIONS

- o FOUR TIMES QUARTERLY FORECAST EQUALS ANNUAL FORECAST
  - oo ANNUAL RECURRING DEMAND FORECAST = 4 (B023D)
  - oo ANNUAL RFI REGENERATIONS FORECAST = 4 (B023F)
  - oo ETC.
- o LEADTIME DEMAND RANDOM VARIABLE HAS ONE OF THESE PROBABILITY DISTRIBUTIONS:

  POISSON, NEGATIVE BINOMIAL, OR NORMAL
- o DEMAND AND REPAIR REGENERATIONS CONTINUOUS RANDOM VARIABLES
  - oo PROCUREMENT/REPAIR ACTIONS GENERATED PRECISELY WHEN ASSETS REACH REORDER/REPAIR POINT

Slide #49

IMPLEMENTATION ASSUMPTIONS
(Continued)

D. Quarterly-Annual Forecast

Assumption: four times the quarterly recurring demand average forecast equals the annual recurring demand average forecast. Similarly, for carcass returns and RFI regenerations. This is a reasonable assumption given the forecasting time-base of one quarter. However, in certain instances of slow-moving items with many zero observations, quarterly time-base forecasting can produce significantly different averages than annual time-base forecasting. Of course, the question is which provides the best estimate of the future.

E. Leadtime Demand Random Variable

Assumption: leadtime demand is generated by a process characterized by either a Poisson, negative binomial or normal distribution. No one knows the underlying probability distribution; few if any systems collect leadtime demand observations in sufficient numbers to determine the probability distribution from empirical data, especially by each line item. Furthermore, it is doubtful the underlying process is stationary over the period necessary to collect such observations. Therefore, one selects probability distributions primarily on a theoretical basis. That is the basis of Navy's selection of those three distributions.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

GOALS FOR USAGE OF MODELS

- o BUDGET FORMULATION
  - oo STRATIFICATION: UICP PROGRAM B20
  - oo PARAMETERS FOR LEVELS SET TO ACHIEVE A PROJECTED 85% REQUISITION FILL RATE
    - BY COGNIZANCE SYMBOL
    - BY 4-DIGIT COGNIZANCE SYMBOL
  - oo EXCEPTIONS TO 85% REQUISITION FILL RATE
    - FBM WEAPON SYSTEM SUPPORT: 95%
    - NUCLEAR PROPULSION SUPPORT: 95%
    - TRIDENT HULL SUPPORT: 90%
- o BUDGET EXECUTION
  - oo CYCLIC FORECASTING AND LEVELS: UICP PROGRAM D01
  - oo PARAMETERS FOR LEVELS SET TO MEET BUDGET CONSTRAINT
    - BY COGNIZANCE SYMBOL
    - ATTEMPT TO MAXIMIZE FILL RATE AND MINIMIZE WORKLOAD WITHIN BUDGET CONSTRAINT

Slide #50

GOALS FOR USAGE OF MODELS

A. Budget Formulation

Budget formulation commences with the Stratification output from UICP program B20. The parameters utilized by the ICPs in Stratification to set inventory levels are selected to achieve an 85% fill rate by cognizance symbol category or four-digit cognizance symbol category, except for selected weapon system. The goals for the exceptions to the 85% fill rate are dictated by CNO and are shown here.

B. Budget Execution

The UICP program for setting inventory levels for budget execution is the Cyclic Forecasting and Levels program (D01). In this program, the parameters are selected to live within budget constraints, for the overall cognizance category, while attempting to maximize requisition fill rate and minimize workload.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PARAMETERS AND CONSTRAINTS - NONPROGRAM RELATED

- o ORDER QUANTITY
  - oo BASIC ORDER QUANTITY

$$Q = \text{MIN}\left[\begin{array}{ll} \text{MIN} & \left\{\begin{array}{l} 4\ (D - B)\ S \\ 4\ (D - B) \div \alpha \\ \text{MAX}\ [25 \div C;\ 12\ (D - B)] \end{array}\right\} \\ \text{MAX} & \left\{\begin{array}{l} 1 \\ D - B \\ \sqrt{\dfrac{8\ (D - B)\ (A + A')}{IC}} \end{array}\right\} \end{array}\right]$$

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PARAMETERS AND CONSTRAINTS

A. Order Quantity

This section of the presentation discusses the parameters and constraints imposed on the basic computation formulas derived from the TVC equations. As shown here the constraints on the basic order quantity from top to bottom are:

> not more than the shelf life quantity; S is shelf life in years and (D-B) is the quarterly attrition demand average forecast.
>
> not more than the obsolescence quantity; a is the obsolescence rate (units per year).
>
> not more than the larger of $25 worth or 3 years worth of attrition demand (of DODI 4140.39).

[Note: The minimum of those constraints, for all practical puposes, means 3 years attrition demand since: S is generally greater than 3, a is less than 0.333 and 25÷C is rarely active]

> not less than 1 unit; an obvious constraint.
>
> not less than (D-B); the 3 month constraint of DODI 4140.39.

The square root formula is the approximation derived from the TVC equation discussed in a *preceding* section.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PARAMETERS AND CONSTRAINTS - NONPROGRAM RELATED

WHERE D = RECURRING DEMAND AVERAGE FORECAST = B023D
B = RFI REPAIR REGENERATIONS AVERAGE FORECAST = B023F
S = SHELF LIFE (YEARS) = C028
α = OBSOLESCENCE RATE = B057
C = UNIT COST = B055
A = ICP PROCUREMENT ADMINISTRATIVE COST
A' = MANUFACTURER SETUP COST = B058
I = HOLDING RATE COMPOSED OF: TIME PREFERENCE RATE = V101 (CONSUM)
V101A (REPAIR)
OBSOLESCENCE RATE = B057
STORAGE COST = 0.01

oo CONSTRAINED ORDER QUANTITY ($\hat{Q}$)

$$\hat{Q} = \text{MAX} \left\{ \begin{array}{l} 1 \\ D - B \\ \text{MIN} \left\{ \begin{array}{l} Q \\ 4\,(D - B)\,S - \text{MAX}\,[0;\ X - Z] \\ \dfrac{4\,(D - B)}{\alpha} - \text{MAX}\,[0;\ X - Z] \end{array} \right\} \end{array} \right\}$$

= B070, IF LIFE OF TYPE BUY DATA IS LOADED

Slide #52

PARAMETERS AND CONSTRAINTS
(Continued)

Once the basic order quantity (Q) and the reorder point (X) is computed, the basic order quantity is constrained as shown here to insure:

the order quantity is not less than 1 unit; a logical constraint.

the order quantity is not less than 3 months attrition demand (D-B).

the maximum theoretical on hand does not exceed the shelf life quantity or the obsolescent quantity.

[Note: If a life of type buy has been made and the quantity is loaded into the UICP data element B070, that quantity becomes the constrained order quantity and the reorder point is set at zero.]

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

<u>PARAMETERS AND CONSTRAINTS - NONPROGRAM RELATED</u>

WHERE Q = BASIC ORDER QUANTITY

X = CONSTRAINED REORDER LEVEL

Z = PROCUREMENT LEADTIME DEMAND AVERAGE

LOT = LIFE OF TYPE BUY = B070

- o REORDER LEVEL
  - oo ECONOMIC RISK ($RISK_E$)

CONSUMABLES: $RISK_E = \frac{DIC}{DIC + \lambda FE}$

REPAIRABLES: $RISK_E = \frac{DICQ}{DICQ + 4\lambda FE\ (D - B)}$

WHERE λ = PROCUREMENT SHORTAGE COST: V103, CONSUMABLES
V104, REPAIRABLES

F = REQUISITION FREQUENCY AVERAGE FORECAST = A023B

E = ITEM ESSENTIALITY = C008C

Q = BASIC ORDER QUANTITY

Slide #53

PARAMETERS AND CONSTRAINTS
(Continued)

B. Reorder Level

The computation of the reorder point begins with the computation of the economic risk ($RISK_E$) as shown here.

PARAMETERS AND CONSTRAINTS - NONPROGRAM RELATED

oo CONSTRAINED RISK ($RISK_C$)

$$RISK_C = MIN \left\{ \begin{array}{c} \text{MAX. ALLOWABLE RISK} \\ MAX \left\{ \begin{array}{l} RISK_E \\ \text{MIN. ALLOWABLE RISK} \end{array} \right\} \end{array} \right\}$$

WHERE: MAX. ALLOWABLE RISK = V102
MIN. ALLOWABLE RISK = V022

oo BASIC REORDER LEVEL (X)

COMPUTED FROM CONSTRAINED RISK, PROCUREMENT LEADTIME
DEMAND VARIANCE (B019A), PROCUREMENT LEADTIME
DEMAND AVERAGE (Z) AND PROBABILITY DISTRIBUTION

POISSON, IF MARK 0 CONSUMABLE ITEM
NEGATIVE BINOMIAL, IF $Z < V028$
NORMAL, IF $Z \geq V028$

Slide #54

PARAMETERS AND CONSTRAINTS
(Continued)

In order to insure that the system is not exposed to too large a risk of stock-out on items, the ICPs may set a maximum allowable risk (parameter V102) to constrain the theoretical degree of risk to be taken. Furthermore, to insure the system does not have extremely large safety levels on items--especially for low cost items--the ICPs may set a minimum allowable risk (parameter V022) to constrain the magnitude of safety levels.

Slide #54 (Continued)

PARAMETERS AND CONSTRAINTS
(Continued)

After obtaining the constrained risk, the basic reorder level (X) is computed utilizing the constrained risk, the procurement leadtime demand variance (data element B019A), the procurement leadtime demand average and the assumed probability distribution. For the Navy, the observations of leadtime demand are assumed to be distributed in accordance with the following probability distribution functions:

Poisson, if the item is a Mark 0 consumable.

Negative Binomial, if the leadtime demand average forecast is less than an ICP-set parameter (V028).

Normal, if the leadtime demand average forecast is greater than or equal to the ICP-set parameter (V028).

Typical ICP-set V028 values are 0 or 20. Note: if V028=0, all items except Mark 0 consumables are assumed to have leadtime demand distributions of the normal probability function.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PARAMETERS AND CONSTRAINTS - NONPROGRAM RELATED

oo CONSTRAINED REORDER LEVEL ($\hat{X}$)

$$\hat{X} = \text{MAX} \left\{ \begin{array}{l} 0 \\ \text{B020} \\ (\text{V295})\ (Z) \\ \text{MIN} \left\{ \begin{array}{l} Z + (K)\ (\text{B023D}) \\ \text{MAX}\ [X;\ \text{NUMBER OF POLICY RECEIVERS}] \\ 4\ (D - B)\ S + (Z) - (\text{C021B}) \\ \dfrac{4\ (D - B)}{\alpha} + (Z) - (\text{C012B}) \end{array} \right\} \end{array} \right\}$$

WHERE:

B020 = REORDER LEVEL LOW LIMIT QUANTITY

V295 = PERCENT OF PROCUREMENT LEADTIME DEMAND

K = MINIMUM SAFETY LEVEL CONSTRAINT

C021B = QUANTITY PER UNIT PACK

$\hat{X}$ = CONSTRAINED REORDER LEVEL = B019

$\hat{X}$ IS SET TO ZERO IF: B070 $\neq$ 0 (LIFE OF TYPE BUY QUANTITY)

$Z \leq 0$

IF (B023D - B023F) $\leq$ 0, $\hat{X}$ = MAX [0, Z]

Slide #55

PARAMETERS AND CONSTRAINTS
(Continued)

The basic reorder level is constrained in many ways:

It can be no smaller than zero.

It can be no smaller than a Numeric Stockage Objective (NSO) quantity if UICP data element B020 is loaded for essentiality considerations.

It can be no smaller than a percentage of the leadtime demand average forecast; the percentage (V295) is an ICP-set parameter.

The safety level can be no larger than a percentage of the gross recurring demand average forecast (B023D); the percentage (K) is an ICP-set parameter.

Note: Current parameter values are:

	ASO	SPCC
V295	1.0	0.0
K	1.3	0.0

The reorder point cannot be smaller than the number of designated wholesale stock points (policy receivers).

The on hand assets are no larger than the shelf life or obsolescence quantities.

Slide #55 (Continued)

PARAMETERS AND CONSTRAINTS
(Continued)

[Note: If a Life of Type quantity is set (data element B070), the constrained reorder point (X) is set at zero and the constrained order quantity is set at the value in B070. If the leadtime demand average forecast is less than or equal to zero--the RFI regenerations over leadtime are significantly larger than demand over leadtime plus regenerations over repair cycle time--the constrained reorder point is set at zero.

Also if the attrition demand is less than or equal to zero--the RFI regenerations average forecast is larger than the recurring demand average forecast--the constrained reorder point is set at the larger of zero or the leadtime demand average forecast.]

PARAMETERS AND CONSTRAINTS - NONPROGRAM RELATED

o. REPAIR QUANTITY

oo BASIC REPAIR QUANTITY (Q_2)

$$Q_2 = \text{MAX} \left\{ \begin{array}{l} 1 \\ (\text{V039})\ (\text{B}) \\ \sqrt{\dfrac{8\ \text{MIN}\ [\text{D};\ \text{B}]\ (A_2 + A_2')}{I_2 C_2}} \end{array} \right\}$$

WHERE: V039 = REPAIR REVIEW CYCLE

A_2 = ICP REPAIR ADMIN COST = V016

A_2' = DEPOT REPAIR SETUP COST = B058A

C_2 = UNIT REPAIR COST = B055A

I_2 = HOLDING RATE COMPOSED OF:

- TIME PREFERENCE = V108
- OBSOLESCENCE = B057
- STORAGE COST = 0.01

Slide #56

PARAMETERS AND CONSTRAINTS
(Continued)

C. Repair Quantity

The repair quantity computed using the approximate formula is constrained to be:

No smaller than one unit.

No smaller than the average regenerations between runnings of the Repair Scheduling program (V039 X B).

Current values for V039: ASO 0.077; SPCC 0.0.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PARAMETERS AND CONSTRAINTS - NONPROGRAM RELATED

oo CONSTRAINED REPAIR QUANTITY ($\hat{Q}_2$)

$$\hat{Q}_2 = \text{MAX} \left\{ \begin{array}{l} 1 \\ \text{MIN} \left\{ \begin{array}{l} Q_2 \\ 4DS - \text{MAX}[\hat{X}_2 - (B023H);\ 0] \\ \frac{4\ D}{\alpha} - \text{MAX}[\hat{X}_2 - (B023H);\ 0] \\ LOT - \hat{X}_2 \end{array} \right\} \end{array} \right\}$$

WHERE: B023H = DEPOT LEVEL TURNAROUND TIME DEMAND AVERAGE
IF D, B OR B023H = 0, $\hat{Q}_2$ IS SET TO 1

o REPAIR LEVEL

oo ECONOMIC RISK ($RISK_{2E}$)

$$RISK_{2E} = \frac{Q_2 I_2 C_2 \bar{D}}{Q_2 I_2 C_2 \bar{D} + 4\lambda_2 FEB}$$

Slide #57

PARAMETERS AND CONSTRAINTS
(Continued)

After the constrained repair point is obtained, the basic repair quantity is constrained to:

Be no smaller than one unit.

Have no more RFI assets than the shelf life demand.

Have no more RFI assets than the obsolescence demand.

Have no more RFI assets than the Life of Type buy quantity.

D. Repair Level

The computation of the repair level begins with the computation of economic repair risk ($RISK_{2E}$), as shown here.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PARAMETERS AND CONSTRAINTS - NONPROGRAM RELATED

WHERE:

Q_2 = BASIC REPAIR QUANTITY
C_2 = UNIT REPAIR COST = B055A
D = QUARTERLY DEMAND AVERAGE FORECAST = B074
λ_2 = REPAIR SHORTAGE COST = V107
I_2 = HOLDING RATE COMPOSED OF: TIME PREFERENCE RATE = V108
OBSOLESCENCE RATE = B057
SHORTAGE RATE = 0.01

oo CONSTRAINED RISK (RISK$_{2C}$)

$$RISK_{2C} = MIN \left\{ \begin{array}{l} \text{MAX. ALLOWABLE RISK} \\ MAX \left\{ \begin{array}{l} RISK_{2E} \\ \text{MIN. ALLOWABLE RISK} \end{array} \right\} \end{array} \right\}$$

WHERE: MAX. ALLOWABLE RISK = V102
MIN. ALLOWABLE RISK = V022

oo BASIC REPAIR LEVEL (X_2)

COMPUTED FROM CONSTRAINED RISK (RISK$_{2C}$), DEPOT LEVEL TURNAROUND TIME DEMAND VARIANCE (B019C), DEPOT LEVEL TURNAROUND TIME DEMAND AVERAGE (B023H), AND PROBABILITY DISTRIBUTION

Slide #58

PARAMETERS AND CONSTRAINTS
(Continued)

In a manner similar to the procurement risk, the economic repair risk is constrained. Also the basic repair point is computed using constrained risk, depot level TAT demand variance, depot level TAT demand average and probability distribution--in a manner similar to the computation of the basic reorder point.

PARAMETERS AND CONSTRAINTS - NONPROGRAM RELATED

NEGATIVE BINOMIAL, IF B023H < V028
NORMAL DISTRIBUTION, IF B023H ≧ V028

oo CONSTRAINED REPAIR LEVEL ($\hat{X}_2$)

$$\hat{X}_2 = \text{MAX}\left\{\begin{array}{l} 0 \\ \text{MIN}\left\{\begin{array}{l} \text{MAX } [X_2;\ \text{NO. OF POLICY RECEIVERS}] \\ 4\ D\ S + \text{B023H} - 1 \\ \dfrac{4\ D}{\alpha} + \text{B023H} - 1 \end{array}\right\} \end{array}\right\}$$

IF D, B OR B023H = 0, $\hat{X}_2$ IS SET TO B023H

o PROCUREMENT LEADTIME DEMAND VARIANCE (B019A)

oo FORMULA FOR MARK I CONSUMABLE ITEMS

$$\text{B019A} = [\text{V023 } (Z)^{\text{V024}} + \text{V025}]^2$$

oo FORMULA FOR MARK III CONSUMABLE ITEMS

$$\text{B019A} = [\text{V023A } (Z)^{\text{V024A}} + \text{V025A}]^2$$

Slide #59

PARAMETERS AND CONSTRAINTS
(Continued)

It should be noted, the probability distribution selection breakpoint (V028) is compared to the depot level TAT demand average (vice the leadtime demand average in computing the procurement problem).

The basic repair point is then constrained to:

Be no smaller than zero.

Be no smaller than the number of designated wholesale stock points.

Have no more RFI assets than shelf life and obsolescence requirements.

Also if recurring demand average, RFI regenerations average or depot level TAT demand average (data element B023H) is equal to zero, the constrained repair level (X_2) is set to the depot level TAT demand average.

Slide 59 (Continued)

PARAMETERS AND CONSTRAINTS
(Continued)

E. Procurement Leadtime Demand Variance

The procurement leadtime demand variance for slow-moving consumable items is computed directly from the procurement leadtime demand average. For Mark 0 consumables, the variance of leadtime demand is equal to the procurement leadtime demand average since we assume the Poisson distribution. For Mark I and Mark III consumables, the variance is computed using an exponential power rule involving the procurement leadtime demand average (Z) as shown here. Current ICP parameter values are:

		ASO	SPCC
Mark I consumables variance forecast coefficient	V023	1.368	2.028
Mark I consumables variance forecast power	V024	0.712	0.701
Mark I consumables variance forecast additive	V025	0	0
Mark III consumables variance forecast coefficient	V023A	1.368	2.028
Mark III consumables variance forecast power	V024A	0.712	0.701
Mark III consumables variance forecast additive	V025A	0	0

The procurement leadtime variance (data element B019A) for other items is computed in accordance with formulas involving the random variables of recurring demand, carcass returns, repair survival rate, procurement leadtime, and repair cycle time; formulas which have been discussed in previous sections of this presentation.

PARAMETERS AND CONSTRAINTS - NONPROGRAM RELATED

- oo CONSTRAINTS

  IF $Z < 0$, B019A IS SET TO ZERO

  IF $(D-B)<0$, B019A IS SET TO ZERO

- o DEPOT LEVEL TURNAROUND TIME DEMAND VARIANCE (B019C)

- oo FORMULA

$$B019C = \overline{T}_2 \text{ VAR } (D) + \overline{D}^2 \text{ VAR } (T_2)$$

WHERE: $\overline{T}_2$ = DEPOT LEVEL TAT AVERAGE = B074

$\overline{D}$ = QUARTERLY RECURRING DEMAND AVERAGE = B074

VAR (T_2) = $[1.25\ (B012D)]^2 + V189$, REPORTING

$[1.25\ (B012B)]^2$, NONREPORTING

- oo CONSTRAINTS

  IF D, B OR B023H = 0, B019C IS SET TO ZERO

Slide #60

PARAMETERS AND CONSTRAINTS
(Continued)

Regardless of how the procurement leadtime demand variance is computed, the value of data element B019A is set to zero if the procurement leadtime demand average is less than zero or the attrition demand average forecast is less than zero.

F. Depot Level TAT Demand Variance

The depot level TAT demand variance is computed in accordance with the formula shown here (see Parzen, as discussed before). It is noted that the value of data element B019C is set to zero if either the recurring demand average forecast, the RFI regenerations average forecast or the depot level TAT demand average forecast is zero.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

SENSITIVITY OF PARAMETERS AND CONSTRAINTS

- o ORDER QUANTITY
  - oo BASIC FORMULA: $$Q_W = \sqrt{\frac{8\ (D - B)(A + A')}{IC}}$$
  - oo MOST COMMON ACTIVE CONSTRAINTS

    $$Q = \text{MIN}\ \{12\ (D - B),\ \text{MAX}\ [1,\ (D - B),\ Q_W]\}$$
  - oo ICP-CONTROLLED PARAMETERS:

    A = ICP ADMINISTRATIVE COST TO ORDER

    A'= MANUFACTURER'S SETUP COST

    I = HOLDING COST RATE
  - oo PARAMETER VALUES

    ICP HAS MOST LATITUDE IN SETTING A VALUES

    NEARLY ALL A' VALUES SET AT ZERO

    HOLDING COST RATE (I) RELATIVELY FIXED AT 0.21 (REPAIRABLES) AND 0.23 (CONSUMABLES)

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Slide #61

SENSITIVITY OF PARAMETERS & CONSTRAINTS

A. Order Quantity

As was seen in the preceding sections, the basic order quantity formula used is the Wilson EOQ formula shown here. The formula is utilized for all items and is the square root of:

- o 2 times the annual attrition demand (represented by 8 times the quarterly attrition demand forecast). Attrition demand is the quarterly recurring demand average forecast (D) minus the quarterly repair regenerations average forecast(B).

Times

- o The sum of the ICP administrative cost of placing an order (A) and the manufacturer's setup cost (A').

Divided by

- o The holding cost per unit per year (IXC).

Although in the preceding sections, it was shown that there are several constraints upon the order quantity, the most common constraints are those shown here:

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SENSITIVITY OF PARAMETERS & CONSTRAINTS

3 years attrition demand (represented by 12 times the quarterly attrition demand forecast (D-B)).
3 months attrition demand (represented by one quarter's attrition demand forecast).
One.

The ICP is permitted to set the parameters of ICP administrative cost (A), manufacturer's set-up cost (A') and holding cost rate (I). In actual practice, the ICP must develop the ICP administrative cost in accordance with the concept expressed in DODI 4140.39; the manufacturer's set-up cost must be based on information obtained from a manufacturer (since little information has been gathered, nearly all items have zero values for A'); the elements of the holding cost rate are relatively fixed to values provided to the ICP (10% investment cost from DODI 4140.39, 1% storage cost from DODI 4140.39, and obsolescence cost from NAVSUP except for known system phase-out).

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

SENSITIVITY OF PARAMETERS AND CONSTRAINTS

- oo CONSTRAINTS IMPACT FOR COMMONLY USED PARAMETER VALUES

  FOR 3 MONTHS DEMAND: VALUE OF QUARTERLY ATTRITION DEMAND OF >~$5,400

  FOR 3 YEARS DEMAND: VALUE OF QUARTERLY ATTRITION DEMAND OF <~$40

  FOR 1 UNIT: RARELY OCCURS FOR DEMAND BASED ITEMS; OCCURS FOR EXTREMELY LOW DEMAND/HIGH COST ITEMS (ESPECIALLY FOR REPAIRABLES)

- oo EXAMPLE: CONSUMABLE

  LET D = 7.828 C = 337.00 A = 200.00 I = 0.23 A' = 0

$$Q_W = \sqrt{\frac{(8)(7.828)(200)}{(0.23)(337)}} = 12.7 \sim 13$$

$$Q = \text{MIN}\{(12)(7.828), \text{MAX}[1, 7.828, 13]\} = 13$$

- o REORDER POINT

  - oo COMPUTED VIA RISK AND PROBABILITY DISTRIBUTION OF LEADTIME DEMAND

  - oo BASIC RISK FORMULA ($RISK_E$)

    CONSUMABLE: $\frac{DIC}{DIC + \lambda FE}$ REPAIRABLE: $\frac{QICD}{QICD + 4\lambda FE(D-B)}$

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SENSITIVITY OF PARAMETERS & CONSTRAINTS

For typically used parameter values:

The 3 months demand constraint is effective for items with value of quarterly attrition demand (VQD) of more than $5400.

The 3 years demand constraint is effective for items with VQD of less than $40.

The one unit constraint becomes a bound on extremely high cost slow moving items--especially repairables.

Turning to an example of an order quantity computation in UICP for a consumable item, as shown the *Wilson EOQ formula provides* an order quantity of 12.7 units which is rounded to 13 units. Furthermore, the constraints of 3 years, 3 months or 1 unit are not active bounds.

B. Reorder Point

As discussed before, the reorder point computation starts with the computation of RISK and the assumption of the probability distribution of leadtime demand.

The basic ecomonic RISK formulas are shown here. The principal parameter controlled by the ICP in the computation of RISK is the shortage cost (λ). As discussed in earlier sections, the essentiality multiplier (E) is a constant across all items. The element F is the quarterly average requisition frequency forecast. Recall that RISK is the probability that a stockout will occur in an order cycle.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

SENSITIVITY OF PARAMETERS AND CONSTRAINTS

- oo COMMON ACTIVE RISK CONSTRAINTS

  ACCEPTABLE RISK = $MIN\{RISK_{MAX}, MAX[RISK_E, RISK_{MIN}]\}$

- oo ICP-CONTROLLED PARAMETERS

  I = HOLDING COST RATE — λ = SHORTAGE COST

  $RISK_{MAX}$ = MAXIMUM ACCETABLE RISK — $RISK_{MIN}$ = MINIMUM ACCEPTABLE RISK

- oo PARAMETER VALUES

  HOLDING COST RATE (I) RELATIVELY FIXED

  ICP HAS MOST LATITUDE IN SETTING VALUES FOR λ, $RISK_{MAX}$, $RISK_{MIN}$

  NAVSUP POLICY FOR CONSUMABLES:

  $RISK_{MIN}$ = 0.01

  $RISK_{MAX}$ = 0.35 FOR WEAPON SYSTEMS WITH 95% SMA GOAL
  = 0.40 FOR OTHER ESSENTIAL WEAPON SYSTEMS
  = 0.50 FOR OTHER WEAPON SYSTEMS

- oo CONSTRAINTS IMPACT FOR COMMONLY USED PARAMETER VALUES

  $RISK_{MAX}$ INCREASES SAFETY LEVEL ON HIGH-VALUE-OF-DEMAND ITEMS

  $RISK_{MIN}$ DECREASES SAFETY LEVEL ON LOW-VALUE-OF-DEMAND ITEMS

  $RISK_{MIN}$ OF 0.01 INSURES SAFETY LEVEL DOES NOT EXCEED THREE STANDARD DEVIATIONS OF LEADTIME DEMAND

Slide #63

SENSITIVITY OF PARAMETERS & CONSTRAINTS
(Continued)

The economic RISK is passed through a maximum and a minimum constraint to acheive an acceptable RISK value. The maximum and minimum constraints are ICP-controlled parameters which are set for each category of items, called a four-digit cog. Although the ICP can control those values, the Naval Supply Systems Command Headquarters (NAVSUP) has established guidelines for setting the RISK constraints for consumables. Those guidelines are that the minimum RISK constraint will be no smaller than 0.01 (that insures meeting the DODI 4140.39 3σ constraint on safety level); that the maximum RISK constraint will vary depending on the requisition fill rate goal for the respective weapon system (will not be less than 0.35 for weapon system with 95% fill rate goal--e.g., nulear propulsion support; not less than 0.40 for other essential Fleet weapon systems; not less than 0.50 for nonessential weapon systems).

The effect of these constraints is:
- o The maximum RISK will insure at least some degree of safety level on all items; it will "prop up" the safety level on high value of demand items which would otherwise exceed the maximum RISK bound.
- o The minimum RISK will insure that safety levels do not exceed a certain degree on all items; it will decrease the safety level on low value of demand items which would otherwise be smaller than the minimum RISK bound.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

SENSITIVITY OF PARAMETERS AND CONSTRAINTS

oo PROBABILITY DISTRIBUTIONS OF LEADTIME DEMAND

MARK 0 CONSUMABLES: POISSON

ALL OTHERS: NEGATIVE BINOMIAL IF V028 > LEADTIME DEMAND AVERAGE
NORMAL IF V028 $\leqq$ LEADTIME DEMAND AVERAGE

IN GENERAL, FOR RANGE OF RISKS ACCEPTABLE AND CHARACTERISTICS OF ITEMS, NORMAL DISTRIBUTION PROVIDES LARGER SAFETY LEVEL THAN NEGATIVE BINOMIAL

oo SAFETY LEVEL FURTHER CONSTRAINED NOT TO EXCEED:

THREE STANDARD DEVIATIONS OF LEADTIME DEMAND,
OR AVERAGE LEADTIME DEMAND FORECAST

oo EXAMPLE: CONSUMABLE

LET D = 7.828 UNIT/QTR	I = 0.23	F = 5.891 REQN/QTR
C = \$337.00	L = 4.8 QTR	σ = 10.198
λ = \$100	E = 0.5	$RISK_{MAX}$ = 0.40
$RISK_{MIN}$ = 0.01	V028 = 20	

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SENSITIVITY OF PARAMETERS & CONSTRAINTS
(Continued)

The basic assumptions concerning the probability distributions of leadtime demand observations are:

> Mark 0 consumable items' leadtime demands are distributed in accordance with the Poisson probability distribution.
>
> For other items, the ICP can select a breakpoint (parameter V028) of leadtime demand average to permit an assumption of either the negative binomial or the normal distribution.

It is to be noted that the selection of a particular probability distribution will influence the magnitude of the safety level. Simply put, in general, for a RISK within the usually accepted range of RISKs, the normal distribution assumption will provide a larger safety level than the negative binomial assumption.

In addition to the indirect constraints on safety level via RISK, the constraints of DODI 4140.39 (3σ and leadtime demand) are also imposed.

Now, an illustration of the computation for the reorder point, using the example item of the order quantity above:

SENSITIVITY OF PARAMETERS AND CONSTRAINTS

$$RISK_E = \frac{(7.828)(0.23)(337)}{(7.828)(0.23)(337) + (100)(5.891)(0.5)} = 0.673$$

$RISK = MIN[0.40, MAX(0.673, 0.01)] = 0.40$

L x D = (4.8)(7.828) = 37.574, WHICH IS GREATER THAN V028, SO USE NORMAL DISTRIBUTION

T - VALUE FOR RISK = 0.40 AND NORMAL DISTRIBUTION IS 0.253

SAFETY LEVEL = $t\sigma$ = (0.253)(10.198) = 2.58 $\sim$ 3 WHICH IS LESS THAN 3σ AND LESS THAN L x D

REORDER POINT = (L x D) + SL = 37.574 + 2.58 = 41 (ROUNDED UP)

- o REPAIR QUANTITY
  - oo BASIC FORMULA: $$Q_{2W} = \sqrt{\frac{8(A_2 + A_2') \ MIN\ (D,B)}{I_2 C_2}}$$
  - oo MOST COMMON ACTIVE CONSTRAINTS: $$Q_2 = MAX\ [1,\ (B)(V039),\ Q_{2W}]$$
  - oo ICP-CONTROLLED PARAMETERS
    - A_2 = ICP ADMINISTRATIVE COST TO PLACE REPAIR ORDER
    - A_2' = DEPOT REPAIR SETUP COST
    - I_2 = HOLDING COST RATE
    - V039 = PERIOD BETWEEN REVIEW CYCLES

Slide #65

SENSITIVITY OF PARAMETERS & CONSTRAINTS
(Continued)

The first step is the computation of the economic RISK. Plugging the numerial values given on the preceding page into the economic RISK formula for a consumable gives a value of 0.673. Of course if the ICP were to increase the λ value greater than $100, the RISK of stockout could be reduced.

Next is to determine if the economic RISK calculated falls within a range acceptable to the ICP. For this example, we will assume the item is on an essential system and thus the acceptable range of risk is 0.10-0.40. Thus, the computed economic risk is constrained to 0.40.

The average leadtime demand forecast is the product of the average leadtime forecast (L=4.8 quarters) times the average recurring demand forecast (D=7.828 units/quarter), or 37.574, a value greater than the breakpoint (V028=20). Therefore, the normal probability distribution assumption will be utilized. For a risk of 0.40, the number of standard deviations (t) is 0.253. Therefore, the safety level is computed to be t times σ (0.253 X 10.198) or 2.58, which clearly is less than 3σ or the leadtime demand.

The reorder point is the sum of the leadtime demand plus the safety level. That is 37.574 + 2.58.

Slide #65 (Continued)

SENSITIVITY OF PARAMETERS & CONSTRAINTS
(Continued)

C. Repair Quantity

The computation of the repair quantity parallels the computation of the order quantity in that a basic computation is made and then the results are constrained. The basic formula shown here is the Wilson formula with repairable characteristics. The term mim(D,B) is to recognize the possibility of not-ready-for-issue units (carcasses) being a constraint.

Since the repair scheduling program has not been designed to be specifically run on a daily basis, the objective of the constraints, which most often come into play, is to insure the repair quantity is not smaller than the period between the review cycle runs.

The ICP-controlled parameters are subjected to the same restraints as those imposed on the equivalent order quantity restraints.

SENSITIVITY OF PARAMETERS AND CONSTRAINTS

oo PARAMETER VALUES

ICP HAS MOST LATITUDE IN SETTING A_2 VALUES
NEARLY ALL A_2' VALUES SET AT ZERO
HOLDING COST RATE (I_2) RELATIVELY FIXED AT 0.21
V039 SET AT 0.077 AT ASO AND AT 0 AT SPCC

oo EXAMPLE

LET	D = 43.59 UNIT/QTR	C_2 = \$205.00
	CARCASS = 41.4 UNIT/QTR	C = \$5,000.00
	SURVIVAL RATE = 0.98	V039 = 0.2 QTR
	A_2 = \$102.00	I_2 = 0.21
	A_2' = 0	

B = CARCASS x SURVIVAL RATE = 41.4 x 0.98 = 40.57

$$Q_{2W} = \sqrt{\frac{(8)(102)(40.57)}{(0.21)(205)}} = 27.7 \sim 28$$

$$Q_2 = MAX[1, (40.57)(0.2), 28] = 28$$

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SENSITIVITY OF PARAMETERS & CONSTRAINTS
(Continued)

Examining an example, first the average repair regenerations forecast is calculated from the given data. That is, B=carcassesXsurvival rate=40.57. Since that value is less than the average demand forecast (D=43.59) it is used in the basic formula for Q_{2_W}.

The basic formula when plugged with the given data gives a magnitude of 27.7 units which would be rounded to 28. Since the review cycle is so small (18 days) the constrained repair quantity (Q_2) is the basic quantity of 28 units.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

SENSITIVITY OF PARAMETERS AND CONSTRAINTS

- o REPAIR POINT
  - oo COMPUTED VIA RISK AND PROBABILITY DISTRIBUTION OF DEPOT LEVEL TURNAROUND TIME DEMAND
  - oo BASIC RISK FORMULA ($RISK_{2E}$) $\dfrac{Q_2 I_2 C_2 D}{Q_2 I_2 C_2 D + 4\lambda_2 \ FEB}$
  - oo COMMON ACTIVE RISK CONSTRAINTS

    ACCEPTABLE FISK = $MIN\{RISK_{MAX}, MAX[RISK_{2E}, RISK_{MIN}]\}$
  - oo ICP-CONTROLLED PARAMETERS

    I_2 = HOLDING COST RATE

    λ_2 = REPAIR SHORTAGE COST

    $RISK_{MAX}$ = MAXIMUM ACCEPTABLE RISK

    $RISK_{MIN}$ = MINIMUM ACCEPTABLE RISK
  - oo PARAMETER VALUES

    HOLDING COST RATE (I_2) RELATIVELY FIXED AT 0.21

    ICP HAS MOST LATITUDE IN SETTING VALUES FOR λ_2, $RISK_{MAX}$, $RISK_{MIN}$
  - oo CONSTRAINTS IMPACT ON RISK SIMILAR TO THOSE FOR REORDER POINT RISK

Slide #67

SENSITIVITY OF PARAMETERS & CONSTRAINTS
(Continued)

D. Repair Point

The repair point is equivalent to the reorder point and the computations are parallel. The primary difference is that the random variable for the procurement problem is the leadtime demand, while the depot level turnaround time demand is the random variable for the repair problem.

First a basic economic repair RISK is computed in accordance with the formula shown here. The economic repair RISK is passed through an acceptable RISK range, whose limits are ICP-set parameters.

The impact of the RISK constraints on the repair point safety level are similar to the RISK constraints impact on the reorder point safety level.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

SENSITIVITY OF PARAMETERS AND CONSTRAINTS

- oo PROBABILITY DISTRIBUTIONS OF DEPOT LEVEL TURNAROUND TIME DEMAND
  - NEGATIVE BINOMIAL IF V028 > DEPOT LEVEL TAT DEMAND AVERAGE
  - NORMAL IF V028 ≦ DEPOT LEVEL TAT DEMAND AVERAGE
- oo NOT SPECIFIC CONSTRAINTS ON REPAIR SAFETY LEVEL
- oo EXAMPLE

  LET $D = 43.59$ UNIT/QTR, $I_2 = 0.21$, $C = \$5,000.00$, $\sigma_2 = 43.67$

  $B = 40.57$ UNIT/QTR, $RISK_{MAX} = 0.40$, $C_2 = \$205.00$, $T = 1.0$ QTR

  $F = 29.9$ REQN/QTR, $RISK_{MIN} = 0.01$, $\lambda_2 = \$310.00$, $E = 0.5$

  $V028 = 20$ UNITS
- oo $$RISK_{2E} = \frac{(28)(0.21)(205)(43.59)}{(28)(0.21)(205)(43.59)+(4)(310)(29.9)(0.5)(40.57)} = 0.065$$
- oo $RISK_2 = [\text{MIN } 0.40, \text{ MAX}(0.065,\ 0.01)] = 0.065$
- oo DEPOT LEVEL TAT DEMAND AVERAGE = $T \times D = (1.0)(43.59) = 43.59$ WHICH IS GREATER THAN V028, SO USE NORMAL DISTRIBUTION
- oo SAFETY LEVEL = $t\sigma_2 = (1.512)(43.67) = 66.03 \sim 67$
- oo REPAIR POINT = $(T \times D) + SL = 43.59 + 66.03 \sim 110$
- oo MAX. INVENTORY POSITION = REPAIR QUANTITY + REPAIR POINT = $28 + 110 = 138$

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SENSITIVITY OF PARAMETERS & CONSTRAINTS
(Continued)

There are two possible depot level turnaround time demand (DLTATD) probability distribution assumptions--negative binomial and normal. As in the reorder point calculation, there is a breakpoint for the distribution assumptions. If the average DLTATD forecast is less than the ICP-set parameter (V028), a negative binomial distribution is assumed; if greater than V028 a normal distribution is assumed.

In the repair problem there are no direct constraints on the safety level as there was on the reorder point safety level (i.e., 3σ or leadtime demand).

Looking at an example for the given characteristics, the magnitude of the economic repair risk is 0.065, which is well within the acceptable risk range of 0.01-0.40.

The DLTATD average is simply (T=1.0)X(D=43.59)=43.59, which is greater than the ICP-set parameter (V028=20) and implies use of the normal distribution.

From normal distribution tables, a risk of 0.065 equates to 1.512 standard deviations. Thus the repair safety level is (t=1.512)X(σ_2=43.67) or 66.03. The repair point is the sum of the average DLTATD forecast and the repair safety level; that is 43.59 + 66.03 = 109.62, rounded to 110.

Of note, the maximum inventory position is 138 units. On the next chart the procurement problem inventory position for this item will be examined.

SENSITIVITY OF PARAMETERS AND CONSTRAINTS

- PROCUREMENT LEVELS PROBLEM EXAMPLE

IN ADDITION TO PRECEDING REPAIRABLE ITEM CHARACTERISTICS

LET $D = 43.59$ UNIT/QTR $\quad A = \$150 \quad A' = 0 \quad I = 0.21$

$\bar{L} = 6.0$ QTRS $\quad \lambda = 0.21 \quad \sigma = 36.36$

$$Q_W = \sqrt{\frac{8(43.59 - 40.57)(150)}{(0.21)(5000)}} = 1.86 \sim 2$$

$$Q = \text{MIN}\{12(43.59 - 40.57);\ \text{MAX}[1;(43.59 - 40.57);2]\} \sim 4$$

$$\text{RISK}_E = \frac{(4)(0.21)(5000)(43.59)}{(4)(0.21)(5000)(43.59)+(4)(1500)(29.9)(0.5)(43.59-40.57)}$$

$$= 0.403$$

$$\text{RISK} = \text{MIN}\{0.40;\ \text{MAX}[0.403;\ 0.01]\} = 0.40$$

PROCUREMENT LEADTIME DEMAND AVERAGE = (LxD)-(LxB)+(TxB) = (43.59-40.57)(6.0) + (40.57)(1.0) = 58.69 WHICH IS GREATER THAN V028, SO USE NORMAL DISTRIBUTION

SAFETY LEVEL = $t\sigma$ = (0.253)(36.36) = 9.2 ~ 10

REORDER POINT = 58.69 + 9.2 ~ 68

MAX INVENTORY POSITION = ORDER QUANTITY + REORDER POINT = 4 + 68 = 72

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SENSITIVITY OF PARAMETERS & CONSTRAINTS
(Continued)

F. Procurement Levels Problem Example

Looking at the procurement problem for the preceding example, the Wilson formula would provide an order quantity of 2 (rounded). Since that value is less than 3 months attrition demand (43.59-40.57), the order quantity is constrained upward to 4 units.

The economic risk computes to 0.403 which is constrained by the maximum risk constraint to 0.40.

Since the leadtime demand average forecast computes to 58.69 units, the normal distribution is selected since 58.69>V028 of 20.

The safety level is computed to 10 units (rounded) and the reorder point is 68 units (rounded).

The maximum inventory position in the procurement problem is 72 units.

SENSITIVITY OF PARAMETERS AND CONSTRAINTS

oo NOTE: SINCE MAXIMUM REPAIR INVENTORY POSTION IS GREATER THAN MAXIMUM PROCUREMENT INVENTORY POSITION [138 > 72], A CARCASS CONSTRAINED SITUATION WILL ALWAYS OCCUR; CANNOT EXECUTE REPAIR LEVELS

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SENSITIVITY OF PARAMETERS & CONSTRAINTS
(Continued)

The point of this exercise is to show that under the present UICP implementation, it may occur that full repair levels cannot be executed since the procurement levels will constrain the number of carcasses available for repair.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PROBLEM AREAS

- COMPLEXITY OF FORECASTING AND INVENTORY LEVELS MODELS
  - INVENTORY MANAGER CONFUSED UNDERSTANDING
    IMPACT OF CHANGING DATA ELEMENT VALUES
    BELIEVABILITY OF AUTOMATED BUY AND REPAIR RECOMMENDATIONS
- APPROXIMATIONS AND CONSTRAINTS
  - NUMEROUS CONSTRAINTS VIRTUALLY ELIMINATE POSSIBILITY OF OBTAINING MINIMIZATION OF TVC EQUATION
  - APPROXIMATIONS VIRTUALLY ELIMINATE POSSIBILITY OF OBTAINING MINIMIZATION OF TVC EQUATION
- FORECASTING LOW DEMAND ITEMS ON QUARTERLY TIME BASE
  - EXPONENTIAL SMOOTHING OF ZERO OBSERVATIONS
  - FILTERING OF NON-ZERO OBSERVATIONS
- LEADTIME FORECASTING
  - ADMINISTRATIVE LEADTIMES NOT FORECASTED FROM OBSERVATIONS
  - PROCUREMENT AND PRODUCTION LEADTIMES ARE FORECASTED AND FILTERED INDEPENDENT OF EACH OTHER
  - FORECASTING SEVERELY LAGS DURING PERIODS OF RAPID INCREASES AND DECREASES

Slide #71

PROBLEM AREAS

A. Complexity

As with almost everything in a technologically complex environment, the inventory control models are so complex that it is difficult for the average person to fully comprehend them. This situation often leads to confusion on the part of an item manager, especially on his ability to evaluate the impact of data element value changes. Often he is so unsure of the models recommendations that he will make verification computations by hand or impose some rule-of-thumb.

B. Approximations and Constraints

Since Navy has imposed so many approximations and constraints (e.g. Wilson formulation, RISK constraints), it is virtually impossible to minimize the total variable cost equation of DODI 4140.39. Furthermore, the constraints of DODI 4140.39 further inhibit the possibility of a true optimization solution.

C. Forecasting Low Demand Items

The forecasting of items with infrequent, random demands on a quarterly time base presents problems if there are many zero observations and relatively high non-zero observations. The filtering and exponential smoothing routines can bias the forecasts unrealistically.

Slide #71 (Continued)

PROBLEM AREAS

D. Leadtime Forecasting

As we saw earlier, the administrative leadtime is not forecast directly from observations of administrative leadtime. Rather, it is derived as the difference of the procurement leadtime average forecast and production leadtime average forecast. Thus, in order to obtain an updated administrative leadtime average forecast, UICP wairs until the end of production leadtime--a process not responsive to actual changes in the administrative leadtime.

The procurement and production leadtime are forecasted and filtered independently of each other. Therefore, it is possible, and sometimes occurs, that production leadtime is filtered but not procurement leadtime observations (or vice versa). If such occurs and the item manager does not input the filtered (or corrected value) observation, the two forecasts can get out of step and the administrative leadtime can become distorted.

As with any forecasting routine which projects from historical demand via averaging or single exponential smoothing with a weight of less than 1, the forecasting in UICP can severely lag during periods of rapidly increasing and decreasing leadtimes. To overcome this problem, the ICPs must perform manual file maintenance changes to keep the forecasts current.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PROBLEM AREAS

- RECURRING DEMAND FORECASTING
  - NONRECURRING DEMAND NOT COVERED BY PLANNING DATA NOT FORECASTED FOR INVENTORY LEVELS COMPUTATIONS
- INDEPENDENT CALCULATION OF PROCUREMENT AND REPAIR LEVELS
  - CAN LEAD TO NONFEASIBLE SOLUTIONS CARCASS CONSTRAINED ENVIRONMENT
- ABNORMAL OBSERVATION FILTERS
  - BIASED TOWARDS FILTERING HIGH OBSERVATIONS
  - FORECAST OF 0.5 TIMES SUM OF LAST TWO ABNORMAL OBSERVATIONS REACTS TOO STRONGLY TO EXTREME VALUES
  - FILTER VALUES SAME FOR ALL ITEMS

Slide #72

PROBLEM AREAS
(Continued)

E. Recurring Demand Forecasting

The UICP system does not attempt to forecast demand of a nonrecurring nature which is not covered by planning data. Navy is now in the process of establishing policy and procedures in this area.

F. Independence of Procurement and Repair Levels

This problem was discussed in the preceding section by an example showing the inconsistency.

G. Abnormal Observation Filters

The filtering system for demand observations is biased towards filtering high demands since in many instances the observations would have to be negative to be filtered on the low side--an impossible occurrence.

For many items in which the two most recent observations are filtered and the forecast is set at ½ the sum, that forecasting procedure reacts too strongly to such extreme values. Navy is investigating a more realistic filtering and averaging process. It may be that there will be different processes for different types of items.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

RECOMMENDATIONS FOR LONG TERM EFFORT

- POLICY FOR DEMAND FORECASTING
  - RECURRING VS. NONRECURRING DEMANDS
  - VARIANCE FORECASTING
  - TIME-BASE(S) FOR FORECASTING
  - ITEM CATEGORIES
    - COMMODITIES
    - VALUE OF DEMAND
  - PROBABILITY DISTRIBUTIONS
  - EXPONENTIAL SMOOTHING, MOVING AVERAGE, ETC.
- CONSUMABLE ITEM INVENTORY MODEL ATTUNED TO MILITARY ENVIRONMENT
  - ELIMINATION OF UNKNOWN COSTS
  - REALISTIC OBJECTIVE FUNCTION AND CONSTRAINTS
  - MINIMAL EXTRANEOUS CONSTRAINTS ON OPTIMAL SOLUTION
  - MINIMAL USE OF APPROXIMATIONS
- POLICY FOR REPAIRABLE ITEM INVENTORY MODEL
  - ATTUNED TO MILITARY ENVIRONMENT

Slide #73

RECOMMENDATIONS FOR LONG TERM EFFORT

A. Policy for Demand Forecasting

OASD(MRA&L) should establish a policy on demand forecasting. As a minimum, the factors listed here should be considered when developing the policy.

B. Consumable Item Model

The consumable item model of DODI 4140.39 is unrealistic in that the objective function does not state the true objective of most military wholesale inventory systems. OASD(MRA&L) should develop a model more attuned to the military environment. The model should avoid as much as possible:

- Unknown costs which cannot be accurately determined or even "ball parked".
- Constraints which inhibit the optimal solution.
- Approximations which inhibit the optimal solution.

C. Repairable Item Model

As a model for repairable items does not currently exist, OASD(MRA&L) should develop such a model. That model(s) should cover both procurement and repair aspects and be attuned to the "real" objective of the military system.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

RECOMMENDATIONS FOR LONG TERM EFFORT

- o CLEARLY STATED EFFECTIVENESS GOALS
  - oo BUDGET FORMULATION
  - oo BUDGET EXECUTION
- o POLICY OF WHEN TO STOCK/NOT STOCK ITEMS AFTER DEMAND DEVELOPMENT PERIOD
  - oo WHOLESALE RANGE RULE
- o POLICY FOR REPLENISHMENT OF ASSETS SO AS TO MINIMIZE PROBABILITY OF LONG SUPPLY

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RECOMMENDATIONS FOR LONG TERM EFFORT
(Continued)

D. Effectiveness Goals

The implied effectiveness goal of DODI 4140.39 is time-weighted requisitions-short, yet our budget formulation goal is requisition fill rate. Furthermore, a specific goal (e.g., 85% SMA) is not clearly spelled out to all Components to the working level. Thus all Components are not necessarily working from the same base for either budget formulation or execution. It may be that Component differences must be recognized, but such should be spelled out in a policy statement from OASD(MRA&L).

E. Wholesale Range Rule

DODI 4140.42 addresses a range rule within the Demand Development Period (DDP). A policy of a range rule after DDP is not specified. OASD(MRA&L) should promulgate such a policy.

F. Replenishment of Assets

This recommendation is coupled to the demand forecasting policy issue. Both issues should result in establishing rules to prohibit or minimize the procurement or repair of long supply assets during periods of downward trending demand.

3.0 VSL/EOQ PARAMETERS, CONSTRAINTS AND CONTROLS

AIR FORCE
PARAMETERS/CONSTRAINTS
VSL/EOQ

Parameter/ Constraint	Warner-Robbins	San Antonio	Oklahoma City	Ogden	Sacremento
Shortage Cost	660	360	390	380	565
Holding Cost Rate	22%	17%	15%	19%	19%
Cost To Order	471.94 / 312.25	498.48 / 283.15	628.28 / 308.16	708.92 / 361.10	473.35 / 365.85
Minimum Order Quantity	6 Months	6 Months	6 Months	6 Months	6 Months
Maximum Order Quantity	3 Years	3 Years	3 Years	3 Years	3 Years

AIR FORCE CONTROLS

VSL/EOQ

Parameter/ Constraint	Shortage Cost	Holding Cost	Cost to Order	Minimum Order Quantity	Maximum Order Quantity
Determined By	HQ AFLC	HQ AFLC	HQ AFLC	OASD	OASD
Approved By	HQ AFLC	HQ AFLC	HQ AFLC	N/A	N/A
Update Frequency	Quarterly	Annually	Annually	N/A	N/A

Army Control of VSL/EOQ Parameters and Constraints

This discussion will focus on the Army's methods for setting and controlling the parameters and constraints used in its VSL/EOQ computation routine. Except for the constraint on maximum safety level, all of the relevant parameters and constraints are kept in the Material Management Decision File (MMD). The maximum safety level constraints from DOD Instruction 4140.39 is hardcoded in the SL computation module. Because of the importance of all elements in the MMD file, and because these usually reflect ICP policy, each ICP has a single group which is responsible for the MMD file. Changes to the MMD must be approved by the Director of Material Management at the ICP and in addition, the parameter values used in VSL/EOQ computation must be approved by DARCOM (DRCMMRS) before they may be put in the MMD file.

The ICP's can control the minimum SL months, and the minimum and maximum EOQ months by setting the constraints in the MMD file. DARCOM policy states that:

SL Minimum Months = 0
EOQ Maximum Months = 36
EOQ Minimum Months = 3

and for the most part all ICPs use these values. There have been ICP violations of this policy, but they have been corrected when found. There is no regular control imposed by DARCOM on constraint values. The maximum SL constraint is hardcoded in the computation and is set to the smaller of expected leadtime demand or 3 standard deviations of leadtime demands as directed by DOD Instruction 4140.39. There is a maximum SL Months constraint in the MMD file which can be set by the ICP. All ICP's, however, have set this to 99 months which effectively renders it inactive.

Army Control of VSL/EOQ Parameters and Constraints

(Continued)

The parameters in the MMD used by VSL/EOQ are: Cost-to-Hold, Cost-to-Procure, and the implied shortage cost, lambda. DARCOM policy is to review the Cost-to-Hold yearly, and the Cost-to-Procure bi-yearly or when a civilian pay raise occurs. There is no operative policy for reviewing lambda values. It has only been in the last 3 to 4 years that ICP's have begun to realize the importance of maintaining the VSL/EOQ parameters. For the most part DARCOM policy is now being followed.

The lambda parameters, which are probably the most important of all the VSL/EOQ parameters, have been virtually ignored throughout DARCOM since they were initially set back in 1974-1977, although two ICP's have recently had their lambda values updated for the first time. With recent concern about stock availability, it is expected that lambda values will be reviewed more frequently in the future.

Values of Army VSL/EOQ Parameters and Constraints

ICP	LAMBDA (Shortage Cost)		Cost to Hold	Cost-to-Procure		
	Stock Fund	Appropriation		Basic Ordering Agreement	Small Purchase	Large Purchase
ARRCOM	475	3300	.15	241	335	1372
CERCOM	510	670	.20	372	320	1096
MICOM	620	3925	.23	409	370	900
TARCOM	275	7800	.15	241	354	1436
TSARCOM	450	9000	.22	295	191	787

DLA VSL/EOQ Forecasting Parameters and Values

The system parameters which govern requirements computations and supply levels at the Defense Supply Centers (DSCs) are maintained in the Requirements Management Policy Tables, one of the master files of the DLA Standard Automated Material Management System (SAMMS). This is a random access file which is kept on line during all daily, weekly, monthly, and quarterly requirements processes. The tables contain many more parameters than are shown here; only those which affect forecasting and levels and are currently in use are shown.

Although some individual parameters are controlled by HQ DLA, the Policy Tables are basically controlled by the DSC Commander and Director of Supply Operations. At the working level, the Management Support Office in the Directorate of Supply Operations is responsible for maintaining current Policy Table listings and preparing transactions to change parameters when required.

The Backorder Formula is the management variable for control of safety level investment. It is controlled by the DSC. The System Constant is automatically computed during the forecast, but can be changed by the DSC through a special data systems application.

The Alpha Factors used in forecasting are controlled by the DSC. The Correcting Alpha Factors are automatically used when the forecast has been two standard deviations in error in the same direction for two successive forecast periods.

DLA VSL/EOQ Forecasting Parameters and Values

(Continued)

The Forecast Returns Percentage is multiplied by the Quarterly Returns forecast to determine the quantity of forecast returns which will be applied as assets in recommended buy processing. It is controlled by the DSC.

The T Factor, EOQ Breakpoints, and EOQ Constraints are controlled by HQ DLA. The Breakpoints (M1, M2, and M3) are functions of the T Factor. The standard EOQ is computed for items with a dollar value of Quarterly Forecast Demand (QFD) between M1 and M2. Items with a dollar value QFD between M2 and M3 have a six month policy EOQ. Items with a dollar value QFD greater than M3 have a three month policy EOQ. The EOQ can be further constrained by the EOQ Constraint Months, depending on the item's dollar value of annual demand.

The ALT/PLT Computation Factor is established by the DSC with HQ DLA approval. It controls the weight placed on the most recent ALT or PLT observation in computing the single smoothed average ALT and PLT.

DLA VSL/EOQ FORECASTING PARAMETERS AND VALUES

Parameter \ DSC	DCSC	DESC	DGSC	DISC	DPSC
Backorder Formula (B)	17,500	39,000	7,500	40,000	1,500
System Constant	74,500,000	85,317,684	84,353,410	123,400,000	31,078,205
(Implied λ)	(677)	(348)	(1,789)	(491)	(3,296)
Normal Monthly Alpha	.05	.10	.10	.05	.10
Normal Quarterly Alpha	.15	.20	.20	.15	.20
Correcting Monthly Alpha	.10	.20	.20	.10	.20
Correcting Quarterly Alpha	.30	.30	.30	.20	.30
Forecast Return Percentage	.50	.50	.50	.50	.35
T Factor	74	74	74	74	95
(Implied Order Cost)	(123)	(123)	(123)	(123)	(134)
(Implied Holding Cost)	(.18)	(.18)	(.18)	(.18)	(.12)
36 Month EOQ Breakpoint (M1)	38	38	38	38	62
6 Month EOQ Breakpoint (M2)	1125	1125	1125	1125	1846
3 Month EOQ Breakpoint (M3)	3750	3750	3750	3750	6267
EOQ Constraint Months Low	36	24	36	36	36
EOQ Constraint Months Med	22	22	22	22	28
EOQ Constraint Months High 1	6	6	6	6	9
EOQ Constraint Months High 2	3	3	3	3	6
ALT/PLT Computation Factor	.67	.67	.67	.67	.67

Navy Parameters, Constraints and Controls

There are several system parameters utilized in UICP in computing forecasts and inventory levels. The total range of system parameters are shown on the attached sheets; these sheets also display the current values utilized by ASO (Aviation Supply Office) and SPCC (Ships Parts Control Center).

The principal parameters directly utilized in the Navy's models for implementing DODI 4140.39 inventory levels are:

Shortage Cost (2) for Consumables Procurement
Levels: UICP Data Element V103

Shortage Cost (2) for Repairables Procurement
Levels: UICP Data Element V104

Shortage Cost (2) for Repairables Repair
Levels: UICP Data Element V107

Probability Distribution Selection Breakpoint:
UICP Data Element V028

Minimum Risk Constraint:
UICP Data Element V022

Maximum Risk Constraint:
UICP Data Element V102

Navy Parameters, Constraints and Controls

(Continued)

Administrative Order Costs

Mark I/II Procurement: UICP Data Element V015
Other Low Value Procurement: UICP Data Element V041
Negotiated Procurement: UICP Data Element V042
Advertised Procurement: UICP Data Element V043
Repair: UICP Data Element V016

Time Preference Rate for Consumables Procurement:
UICP Data Element V101

Time Preference Rate for Repairables Procurement:
UICP Data Element V101A

Time Preference Rate for Repair:
UICP Data Element V108

The time preference rate values (V101, V101A, V108) are set at 10% which is the default value specified by DODI 4140.39. The other principal parameter values, mentioned above, are determined by the respective ICP and are reviewed/approved semi-annually by NAVSUPHQ during the Stratification Validation Reviews.

Navy Parameters, Constraints and Controls

(Continued)

The other parameters shown on the attached sheets are utilized in the forecasting of various random variables means (averages) and mean absolute deviations (variability). The only forecasting parameters which NAVSUPHQ dictates to the ICPs are those parameters defining the Mark categories; the Mark categories are explained in the VSL/EOQ Implementation presentation. The other forecasting parameters are determined and approved internally to the respective ICP.

At SPCC, the Operations Research Analyst periodically reviews the parameters and submits changes to the Commanding Officer for approval via a Stratification Levels Committee and a Budget Council. Those procedures are spelled out in SPCC Internal Instruction 5230.15 series. Basically, levels parameters used in budget execution are reviewed/ approved quarterly, while those used in budget formulation are reviewed semi-annually. Others are reviewed/ approved at least annually (more often if significant conditions change).

At ASO, the Systems Analysis Group reviews budget execution levels parameters quarterly and those for budget formulation semi-annually. The Systems Analysis Group submits changes to the Commanding Officer and the Stratification Steering Group for approval. Similiarly, other parameters are reviewed/ approved at least annually (more often if significant conditions change).

Navy Parameters, Constraints and Controls

(Continued)

As mentioned before, NAVSUPHQ reviews and approves parameters used in budget formulation and in budget execution on a semi-annual basis as part of the on-site Stratification Validation Review. In addition to the on-site reviews, the Commander, NAVSUPHQ requires the ICPs to present their plans for budget execution at the beginning of each fiscal year. The presentation includes any significant changes to be made to any parameter settings. Since several of the parameters used in forecasting have not been changed for several years, NAVSUPHQ has commissioned the Operations Analysis Department of FMSO Fleet Material Support Office) to reevaluate the parameter settings for all parameters used in forecasting (not levels setting). That study is currently in progress.

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PARAMETERS AND CONSTRAINTS VALUES: CONTROLS

NAVSUP CONTROLLED

- MARK BOUNDARIES

  V001A, V001B, V001C, V002A, V002B, V002C,
  V003A, V003B, V003C, V010A, V010B, V010C

ICP CONTROLLED

- SPCC
  - SPCC INTERNAL INSTRUCTION 5230.15A
  - OPERATIONS RESEARCH ANALYST REVIEWS CONSTANTS ON PERIODIC BASIS AND RECOMMENDS VALUES TO COMMANDING OFFICER VIA STRATIFICATION/LEVELS COMMITTEE AND BUDGET COUNCIL
  - COMMANDING OFFICER IS APPROVAL AUTHORITY
  - CONSTANTS REVIEWED QUARTERLY: EXECUTION LEVELS PARAMETERS
  - CONSTANTS REVIEWED SEMI-ANNUALLY: V039, V040, V057, V062, V063, V070, V189/V294 AND STRATIFICATION LEVELS PARAMETERS
  - ALL OTHERS REVIEWED ANNUALLY
  - CHANGES OTHER THAN SEMI-ANNUAL OR ANNUAL IF SIGNIFICANT REAL WORLD CONDITIONS CHANGE

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PARAMETERS AND CONSTRAINTS VALUES: CONTROLS

ICP CONTROLLED (CONTINUED)

- o ASO
  - oo MANAGEMENT SUPPORT DIVISION UPDATES ADMIN COST TO BUY ON AN ANNUAL BASIS
  - oo SYSTEMS ANALYSIS GROUP REVIEWS LEVELS PARAMETERS QUARTERLY FOR EXECUTION AND SEMI-ANNUALLY FOR STRATIFICATION AND RECOMMENDS VALUES TO COMMANDING OFFICER (EXECUTION) AND STRATIFICATION STEERING GROUP (STRATIFICATION)
  - oo OTHER PARAMETERS ARE REVIEWED ANNUALLY OR AS REAL WORLD CONDITIONS CHANGE

FMSO STUDY

- o NAVSUP TASKING OF AUGUST 1979
- o FMSO TO RECOMMEND VALUES
  - oo MAD AND VARIANCE APPROXIMATION PARAMETERS: V023, V023A, V024, V024A, V025, V025A, V060, V061, V062, V063, V067, V068, V004, V005, V007, V300, V301, V302, V303, V304, V305
  - oo FILTERS AND TRENDING PARAMETERS: V008, V008A, V272, V272A, V273, V273A, V273B

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PARAMETERS AND CONSTRAINTS VALUES: CONTROLS

<u>NAVSUP REVIEW</u>

- o STRATIFICATION LEVELS PARAMETERS
  - oo SEMI-ANNUALLY
  - oo PART OF HEADQUARTERS STRATIFICATION VALIDATION PROCESS
- o EXECUTION LEVELS PARAMETERS
  - oo ANNUALLY
  - oo PART OF HEADQUARTERS BUDGET EXECUTION REVIEW

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PARAMETERS AND CONSTRAINTS VALUES: CONTROLS

UICP DATA ELEMENT	DESCRIPTION	ASO VALUE	SPCC VALUE
V001A	UNIT DEMAND LOWER BOUNDARIES	2	2
V001B	UNIT DEMAND BASIC BOUNDARIES	5	5
V001C	UNIT DEMAND UPPER BOUNDARIES	8	8
V002A	DOLLAR DEMAND LOWER BOUNDARIES	30	30
V002B	DOLLAR DEMAND BASIC BOUNDARIES	75	75
V002C	DOLLAR DEMAND UPPER BOUNDARIES	120	120
V003A	COST LOWER BOUNDARIES	20	20
V003B	COST BASIC BOUNDARIES	50	50
V003C	COST UPPER BOUNDARIES	80	80
V004	SYSTEM DEMAND COEFFICIENT	1.518	1.370
V005	SYSTEM DEMAND POWER	0.817	0.717
V007	SYSTEM DEMAND CONSTANT	0	0
V008	FILTER CONSTANT	3.0	6.0
V008A	FILTER CONSTANT, LOW DEMAND CONSUMABLES	15.0	2.0
V010A	MARK O LOWER BOUNDARIES	0.25	0.25
V010B	MARK O BASIC BOUNDARIES	0.25	0.25
V010C	MARK O UPPER BOUNDARIES	0.50	0.50

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PARAMETERS AND CONSTRAINTS VALUES: CONTROLS

UICP DATA ELEMENT	DESCRIPTION	ASO VALUE	SPCC VALUE
V015	MARK I AND II ORDER COST	123.09	155.00
V016	REPAIR ADMINISTRATIVE COST	14.16	155.00
V018	SYSTEM DEMAND/CARCASS RETURN MULTIPLIER	0.40	0.50
V023	SYSTEM LTD COEFFICIENT, MARK I ITEMS	1.368	2.028
V023A	SYSTEM LTD COEFFICIENT, MARK III ITEMS	1.368	2.028
V024	SYSTEM LTD POWER, MARK I ITEMS	0.712	0.701
V024A	SYSTEM LTD POWER, MARK III ITEMS	0.712	0.701
V025	SYSTEM LTD CONSTANT, MARK I ITEMS	0	0
V025A	SYSTEM LTD CONSTANT, MARK III ITEMS	0	0
V033	SAFETY LEVEL CONTROL KNOB	0.812	1
V039	REPAIR REVIEW CYCLE TIME	0.077	0
V040	TIME TO REPORTING SYSTEM ENTRY	0.154	0
V041	LOW VALUE ANNUAL DEMAND ORDER COST	123.09	155.00
V042	NEGOTIATED PROCUREMENT ORDER COST	206.68	450.00
V043	ADVERTISED PROCUREMENT ORDER COST	206.68	500.00
V044	MAXIMUM UNPRICED PURCHASE ORDER VALUE	7,500.00	8,000.00

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PARAMETERS AND CONSTRAINTS VALUES: CONTROLS

UICP DATA ELEMENT	DESCRIPTION	ASO VALUE	SPCC VALUE
V049	MARK II LEADTIME VARIANCE CONSTANT	1.200	1.00
V057	MAXIMUM REPAIR CYCLE TIME	2.00	10.00
V060	SURVIVAL RATE COEFFICIENT	0.800	0.051
V061	SURVIVAL RATE POWER	0.500	0.884
V062	TURNAROUND TIME COEFFICIENT	0.800	0.051
V063	TURNAROUND TIME POWER	0.500	0.884
V066	MAXIMUM ACCEPTABLE PROCUREMENT LEADTIME	10.00	10.00
V067	PROCUREMENT LEADTIME COEFFICIENT	0.800	0.051
V068	PROCUREMENT LEADTIME POWER	0.500	0.884
V070	REPAIR SCHEDULE TIME (DAYS)	14.0	0
V083	REPLENSIHMENT REQUIREMENT VALUE - TERMINATION	25.00	100.00
V084	CONTRACT VALUE FOR TERMINATION	25.00	5,000.00
V085	BUY REVIEW VALUE	5,000.00	0
V101	PROCUREMENT TIME PREFERENCE RATE, CONSUMABLES	0.10	0.10
V101A	TIME PREFERENCE RATE, REPAIRABLES	0.10	0.10
V108	REPAIR TIME PREFERENCE RATE	0.10	0.10

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PARAMETERS AND CONSTRAINTS VALUES: CONTROLS

UICP DATA ELEMENT	DESCRIPTION	ASO VALUE	SPCC VALUE
V115	TERMINATION REVIEW VALUE	5,000.00	100.00
V163	MAXIMUM PROCUREMENT LT OBSERVATION FILTER	2.00	2.00
V164	MINIMUM PROCUREMENT LT OBSERVATION FILTER	0.75	0.50
V165	MAXIMUM PRODUCTION LT OBSERVATION FILTER	2.00	2.00
V166	MINIMUM PRODUCTION LT OBSERVATION FILTER	0.75	0.50
V167	MAXIMUM REPAIR TAT OBSERVATION FILTER	2.00	2.00
V168	MINIMUM REPAIR TAT OBSERVATION FILTER	0.10	0.25
V169	MAXIMUM REPAIR INPROCESS TIME FILTER	2.00	2.00
V170	MINIMUM REPAIR INPROCESS TIME FILTER	0.10	0.25
V189	SYSTEM OST FORECAST, HVM, ETC.	31 DAYS	30 DAYS
V190	SYSTEM OST FORECAST, OTHER ITEMS	60 DAYS	30 DAYS
V193	REPAIR LEVEL 4 REPAIR OBJECTIVE	55 DAYS	90 DAYS
V194	PROCUREMENT LT SMOOTHING WT. - FREQUENT	0.50	0.20
V195	PROCUREMENT LT SMOOTHING WT. - LESS FREQUENT	0.50	0.50
V196	PROCUREMENT LT SMOOTHING WT. - LEAST FREQUENT	0.50	1.00
V197	PRODUCTION LT SMOOTHING WT. - FREQUENT	0.50	0.20

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PARAMETERS AND CONSTRAINTS VALUES: CONTROLS

UICP DATA ELEMENT	DESCRIPTION	ASO VALUE	SPCC VALUE
V198	PRODUCTION LT SMOOTHING WT. - LESS FREQUENT	0.50	0.50
V199	PRODUCTION LT SMOOTHING WT. - LEAST FREQUENT	0.50	1.00
V200	REPAIR INPROCESS SMOOTHING WT. - FREQUENT	0.30	0.2
V201	REPAIR INPROCESS SMOOTHING WT. - LESS FREQUENT	0.30	0.50
V202	REPAIR INPROCESS SMOOTHING WT. - LEAST FREQUENT	0.30	1.00
V203	TAT SMOOTHING WT. - FREQUENT	0.20	0.20
V204	TAT SMOOTHING WT. - LESS FREQUENT	0.10	0.50
V205	TAT SMOOTHING WT. - LEAST FREQUENT	0.30	1.00
V269	MINIMUM BUY VALUE	25.00	25.00
V272	UPWARD TREND SIGNIFICANCE LEVEL	1.50	1.10
V272A	DOWNWARD TREND SIGNIFICANCE LEVEL	0.99	0.90
V273	SMOOTHING WT. - TRENDING MK II AND IV ITEMS	0.40	0.30
V273A	SMOOTHING WT. - TRENDING MK 0, I, III ITEMS	0.40	0.30
V273B	SMOOTHING WT. - NONTRENDING ITEMS	0.20	0.10
V294	SYSTEM OST FOR TAT	0	0
V295	REORDER LEVEL CONSTRAINT RATE	1.0	0
V300	PROCUREMENT VARIANCE COEFFICIENT, CONSUMABLES	750	4.112

NAVY IMPLEMENTATION OF VSL/EOQ POLICIES

PARAMETERS AND CONSTRAINTS VALUES: CONTROLS

UICP DATA ELEMENT	DESCRIPTION	ASO VALUE	SPCC VALUE
V301	PROCUREMENT VARIANCE POWER, CONSUMABLES	1.00	1.402
V302	PROCUREMENT VARIANCE COEFFICIENT, REPAIRABLES	2,000	3.735
V303	PROCUREMENT VARIANCE POWER, REPAIRABLES	1.00	1.443
V304	REPAIR VARIANCE COEFFICIENT	2,000	3.349
V305	REPAIR VARIANCE POWER	1.00	1.464
--	VARIANCE-TO-MEAN RECOMPUTATION BREAKPOINT		
	REPAIRABLES	2,000	150
	CONSUMABLES	750	150

NAVY IMPLEMENTATION ‧ L/EOQ POLICIES

PARAMETERS AND CONSTRAIN VALUES: CONTROLS

UICP DATA ELEMENT	DESCRIPTION	ASO VALUE	SPCC VALUE
V022	SMALLEST ALLOWABLE RISK, CONSUMABLES (STRATIFICATION)	0.01	0.01
V022	SMALLEST ALLOWABLE RISK, REPAIRABLES (STRATIFICATION)	0.05 0.01	0.01
V102	MAXIMUM ALLOWABLE RISK, CONSUMABLES (STRATIFICATION)	0.40	0.50
V102	MAXIMUM ALLOWABLE RISK, CONSUMABLES (STRATIFICATION)	0.40	0.40 0.45
V028	PROBABILITY SELECTION CONSTANT, CONSUMABLES (STRATIFICATION)	20	20
V028	PROBABILITY SELECTION CONSTANT, REPAIRABLES (STRATIFICATION)	0 20	20 8
V103	PROCUREMENT SHORTAGE COST, CONSUMABLES (STRATIFICATION)	VARIES BY WEAPON SYSTEM 15,560-31,500	500
V104	PROCUREMENT SHORTAGE COST, REPAIRABLES (STRATIFICATION)	140,000- 145,500	1,100- 1,900
V107	REPAIR SHORTAGE COST (STRATIFICATION)	175	280- 700

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